THE JOURNAL and CERAMIC ABSTRACTS

AMERICAN CERAMIC SOCIETY

MAY • 1940

MONTHLY PUBLICATION DEVOTED TO THE ARTS AND SCIENCES RELATED TO THE SILICATE INDUSTRIES

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Publication Office: 20th & Northampton Sts., Easton, Pa.
Editorial Office: 2525 N. High St., Columbus, Ohio
Entered as second class matter at the post office at Easton, Pa., under the act of March 3, 1879. Published monthly.
Subscription fifteen dollars ($15.00) a year. Single numbers $1.50
(Foreign and Canadian postage, 50¢ additional on subscriptions)
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EFFECT OF MOLTEN ALUMINUM ON VARIOUS REFRACTORY BRICK*

By H. O. Burrows

Abstract

To study the effect of molten aluminum on refractory brick with a view toward explaining some of the brick failures in aluminum melting furnaces, the following test was conducted. Brick of different compositions and from various manufacturers were placed on end in the bottom of an electrically heated ladle to which molten aluminum was added. After holding the molten aluminum in contact with the brick for thirty-five days, it was poured out and the ladle was allowed to cool slowly to room temperature.

A study of the brick revealed that some failed by penetration of the aluminum into the brick accompanied by a reaction between the aluminum and the brick. This penetration was less with the denser brick than with the more porous ones. Of the brick tested, there was the least reaction between aluminum and the chrome brick and most between aluminum and silica brick. Many other factors, however, must be considered when deciding which brick is the most economical to use in aluminum melting.

I. Introduction

Aluminum is melted in a number of different types and sizes of furnaces, but by far the largest percentage is melted in reverberatory or open-hearth furnaces of 20,000-pound capacity. Furnaces of larger capacity are being built, but the 20,000-pound size is still the most popular. The molten metal in these furnaces is contained in the hearth of refractory material, usually brick.

In melting aluminum in open-hearth furnaces, there is a tendency for aluminum oxide or dross to build up on the furnace walls and in the corners of the hearth. This aluminum oxide is soft and easily removed when it is first formed. If it is allowed to remain for any length of time, it gradually becomes harder, denser, more adherent, and more difficult to remove, and if the accumulation is not removed regularly it will gradually decrease the capacity of the furnace. To remove the aluminum oxide or dross, the hearth and side walls must be scraped vigorously with iron bars and scrapers, and this process sometimes removes the surface of the brick if the oxide has been allowed to accumulate too long.

The change which takes place in converting this loose, highly refractory aluminum oxide into a flintlike, tightly adhering mass at a temperature so far below its melting point is not thoroughly understood. The aluminum oxide at the temperatures found in the melting furnaces is known to be in the form of corundum, and it is still corundum in the hard crust which forms, so that there does not appear to be a phase change in passing from the soft porous to the hard dense form.

A furnace bottom fails occasionally by spalling or crumbling early in the life of the furnace and it requires replacement. It may fail by abrasion or, in some cases, because the top layer of brick in the hearth comes up. A furnace bottom that fails with a large volume of molten aluminum in it may be a serious problem as well as a costly one, and an explanation for the failures was sought.

* Presented at the Autumn Meeting, Refractories Division, Conneaut Lake, Pa., September 8, 1939. Received September 22, 1939.

Representatives from the brick manufacturers were consulted, but they had little information on the effect of molten aluminum on refractory brick. A test was therefore arranged, whereby a number of brick could be tested simultaneously under identical conditions.

This test was conducted in a remelting room under plant supervision, and although it may lack something from a research engineer's viewpoint, it is a practical test which may be translated readily into useful information.

II. Test Procedure

Brick of different compositions were secured from several manufacturers, and an analysis of some of the samples is shown in Table I. All of the samples were marked for identification, weighed, and stood on end in an electrically heated ladle (Fig. 1). The samples were bonded to the bottom of the ladle with a refractory cement to prevent floating. The tops of specimens Nos. 1 to 37, inclusive, were set at the same elevation, while

Table I

Immersion Test of Brick

Specimen No.	SiO_2	Al_2O_3	TiO_2	Fe_2O_3	CaO	MgO	Alkalis
18	50.97	43.03	2.56	1.42	0.15	0.36	1.64
37	"	"	"	"	"	"	"
13	32.48	60.25	3.24	1.63	0.48	0.52	1.62
7	"	"	"	"	"	"	"
12	21.80	71.34	3.34	1.20	0.24	0.51	1.59
8	"	"	"	"	"	"	"
16	38.3	58.1		1.9	0.5	0.5	1.2
4	"	"		"	"	"	"
19	53.1	42.3		2.4	0.7	0.7	1.6
15	"	"		"	"	"	"
27	51.7	42.2		2.3	0.7	0.7	1.5
33	"	"		"	"	"	"
20	51.96	45.38	1.73	0.57	0.10	0.22	
5	"	"	"	"	"	"	
22	43.0	52.0	2.2	1.9	0.35	0.25	0.10
29	"	"	"	"	"	"	"
24	22.50	72.30	3.20	1.40	0.20	0.15	0.25
35	"	"	"	"	"	"	"
26	2.6	0.8		6.3	3.0	86.8	0.5
1	"	"		"	"	"	"
25	2.6	4.0		2.1	1.5	89.5	0.4
9	"	"		"	"	"	"

the tops of specimens Nos. 38 to 44, inclusive, were set about 3 inches above the tops of the other specimens to check the tendency of the aluminum to rise by capillary attraction. Specimens Nos. 42 and 26 were broken laterally across their centers to check the penetration of aluminum into thin layers of refractory cement, and the halves were joined together with refractory cement before they were mounted. Because specimen No. 29 was not received until after the test had been started, it was not introduced into the bath until the eighth day of the test.

FIG. 1.—Electrically heated ladle for tests.

After the specimens were mounted in the ladle they were allowed to air-dry for two days. Power was then turned on, and the temperature in the ladle was slowly raised to 1475°F., which required 50 hours.

A controller was set to maintain a temperature of 1400°F., and after three hours at this temperature, molten aluminum was added to the ladle until the surface of the metal was within 1¾ inches of the top ends of specimens Nos. 1 to 38, inclusive, and 4½ inches from the tops of specimens Nos. 38 to 44, inclusive. Care was taken that no metal should splash up on the specimens. During the ladle-filling operation, specimens Nos. 22 and 36 were accidentally broken loose from their mountings, and after several days they sank.

Previous observations had indicated that where some metal had splashed on the sides of the brick there appeared to be more reaction than at or below the metal level. It was thought that the presence of air or oxygen might accelerate the reaction. To check this, the morning after the ladle was filled, pieces of pure aluminum, 2 by 4 by ⅛ inch, were wiped clean and placed centrally on the tops of the various specimens. After placing these aluminum caps, observations were made at 3-hour intervals for the first 15 hours, at 6-hour intervals for the next 24 hours, at 12-hour intervals for the next 60 hours, and at 24-hour intervals until the conclusion of the test, which lasted thirty-five days.

Shortly after the beginning of the test, dark rings formed around some of the specimens at the surface of the bath. These rings were most noticeable when the cover of the ladle was raised and the tops of the specimens had cooled slightly. They appeared at first merely to mark a temperature zone, but it soon became apparent that the rings were caused by the penetration of metal into the brick. The capillary action of the brick gradually drew the metal up toward the tops of some of the specimens, evidenced by the gradual rise of the dark outlines. The outlines rose quite evenly in some cases, and in others the rise was uneven. Evidence of reaction between the aluminum and the brick is verified by the chemical analysis of the aluminum before and after the test, which shows a gain of about 3¼ % in silicon content.

	Cast No.	Al	Si	Fe	Cu	Mn	Mg
Before immersion	2819	97.96	1.26	0.65	0.05	0.05	0.0
After immersion	2903	94.38	4.50	1.03	0.07	0.02	

At the end of thirty-five days, the metal in the ladle was poured out, and the ladle was allowed to cool slowly to eliminate thermal shock. About three days were required to cool to room temperature. The specimens were then cleaned of superficial débris, weighed, and examined. The gain in weight is shown in Table II, and the specimens are arranged in the order in which they increased in weight.

TABLE II

WEIGHT OF SPECIMENS IN ORDER OF ACTUAL GAIN

Specimen No.	Original weight (lb.)	Gain in weight: Actual (lb.)	Avg. (lb.)	Actual (%)	Avg. (%)	Order of % gain
38	10.31	0.44*		4.27		
39	10.75	0.12*	0.28	1.12	2.69	1
1	9.31	0.19		2.04		
26	9.12	0.44†	0.31	4.83	3.43	2
9	8.94	0.31		3.96		
25	8.75	0.62	0.46	7.09	5.02	3
40	12.06	3.19*	3.19	26.4	26.4	4
2	9.06	2.50	2.50	27.6	27.6	5
34	6.56	1.87	1.87	28.5	28.5	6
32	9.62	3.19	3.19	33.2	33.2	7
8	7.69	2.44		31.8		
12	7.50	3.44	2.94	45.8	38.8	8
5	7.69	3.06		39.8		
20	7.50	2.56	2.81	39.1	39.4	9
7	7.75	2.44		31.7		
13	7.50	3.62	3.03	48.2	39.9	10
3	8.75	3.50		40.0		
17	8.62	3.62	3.56	42.0	41.0	11
41	7.40	3.06*	3.06	41.3	41.3	12
43	7.81	3.31*		42.3		
44	7.81	3.37*	3.34	43.2	42.7	13
15	7.25	2.87		39.6		
19	7.31	3.69	3.28	50.5	45.0	14
6	7.31	3.50		47.8		
11	7.50	3.19	3.34	42.6	45.2	15
18	7.12	3.06		42.9		
37	7.25	4.00	3.53	55.2	49.0	16
4	7.50	3.94		52.6		
16	7.50	4.00	3.97	53.3	52.9	17
21	7.37	4.00		54.3		
36	7.69	4.50	4.25	58.6	56.4	18
24	7.44	4.56		61.2		
35	7.44	4.56	4.56	61.2	61.2	19
27	6.62	4.56		68.8		
33	7.00	4.62	4.59	65.9	67.3	20
23	6.81	5.50		80.7		
28	6.87	4.25	4.87	61.9	71.3	21
22	6.87	4.94		71.9		
29	6.37	5.25	5.09	82.4	77.2	22
14	6.12	5.56		90.8		
30	6.19	6.25	5.90	101.0	95.9	23

* Brick immersed only 4¼ inches; the others 7¾ inches.

† Broken laterally at center and cemented together.

The chrome brick gained the least weight; in fact they lost slightly. The magnesite brick were next, followed by silicon carbide and tank block, the silica brick showing the greatest increase in weight.

The specimens were carefully examined, and some of them were fractured for internal examination.

III. Data on Specimen Brick

Specimens Nos. 39 and 38, Chrome Brick (Fig. 2)

Specimen No. 39: (1) Very thin, but tightly adherent film of metal; (2) rough surface due to anchoring cement only; no appreciable change in color over transverse fractured area; (3) area of same color, but slightly less lustrous than remainder of fractured surface; (4) light spot due to light reflected from face of crystal; and (5) slag, adhering to brick mechanically, fairly easy to crack off with hammer without destroying surface of brick; this extended all around periphery of brick; metal cap adhered mechanically but sufficiently tight so that the brick surface was pulled off when the cap was pried off; apparently no slag penetration.

Specimen No. 38: (1) Very thin but tightly adherent metal skin; (2) same as (1), apparently due to momentary immersion of this part of brick; and (3) adhering slag; fracture of this slag typical of slag on all specimens as to density and hardness, but outside surface is a little rougher; at the bottom, where this brick was broken from the bottom of the ladle, is a canary-yellow discoloration on the fractured surface; this color is similar to that found on specimen No. 31; the cap on top pulled away the surface of the brick at one point. (4) Some slag pried up from face of brick.

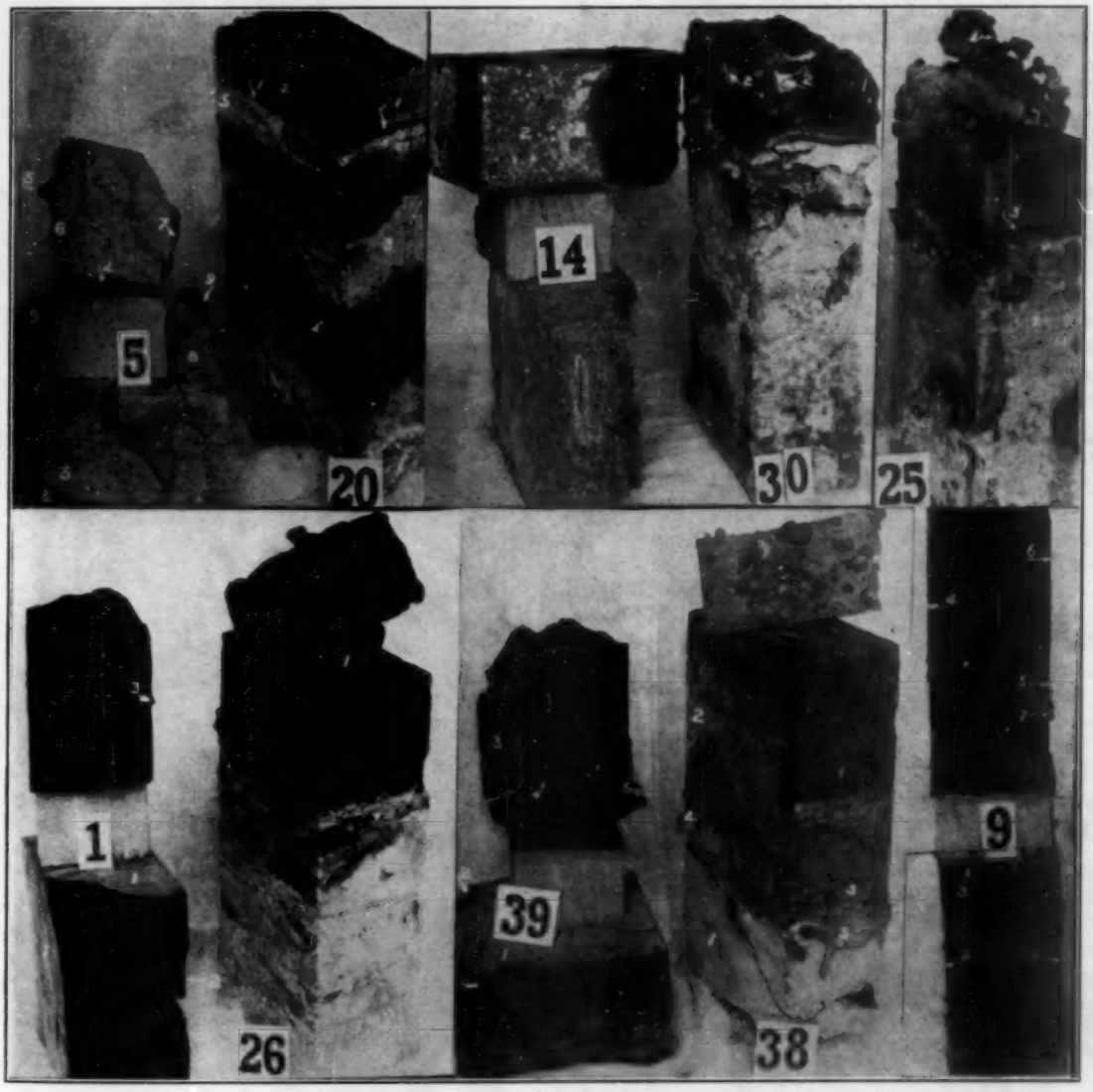

FIG. 2.—Specimens Nos. 39 and 38, chrome brick; Nos. 1 and 26, power-pressed magnesite with 6% iron; Nos. 9 and 25, power-pressed magnesite brick with 2% iron; Nos. 5 and 20, steamed-pressed mullite; Nos. 14 and 30, machine-made silica brick.

Specimens Nos. 1 and 26, Power-Pressed Magnesite with 6% Iron (Fig. 2)

Specimen No. 1: (1) Very thin but tightly adhering film of metal.

(2) Impregnated layer $^1/_{32}$ inch thick; this layer or case existed on all surfaces of the brick below the metal level; immediately below this layer, the color of the brick on the fractured surface is a somewhat lighter shade than the center of the brick for a depth of about $^1/_{16}$ to $^1/_8$ inch.

(3) Nodule of slag adhering to surface of brick; penetration of slag at the metal line was not so deep as that below the metal line; the slag may be readily pried off, but the surface of the brick is generally pulled off when the slag is pried off. The aluminum cap broke off during handling, apparently without affecting the top surface of the specimen; at places on top of the specimen there remained a fairly tightly adhering deposit; this deposit on top was easily powdered and flaked off when scraped without pulling out the surface of the brick; this condition may be seen at (1) on specimen No. 26.

Specimen No. 26: This specimen was broken at the middle from edge to edge and cemented together with refractory cement; the appearance of the surface of this brick, the penetration of the metal below the metal level, and the adherence of the slag was practically the same as specimen No. 1. At the joint between the broken halves of the brick, all the cement in the joint, which was about $^1/_{16}$ inch thick, had penetrated to the center of the brick; the fracture of the cement showed the characteristic gray, almost metallic luster. There was some evidence that the magnesite adjacent to the cement in the interior of the brick had also been attacked the same as the surface of the brick.

Specimens Nos. 9 and 25, Power-Pressed Magnesite with 2% Iron (Fig. 2)

Specimen No. 9: The transverse fracture showed a considerable depth of penetration or case. This case was heaviest ($^3/_{16}$ inch) on the brand side at (1) and lightest ($^1/_{16}$ inch) on the opposite side at (2). On the $2^1/_2$-inch face, the case was about $^1/_8$ inch. The outside surface of the case was a dark gray, similar to that on fireclay brick. Next to this, particularly on the $2^1/_2$-inch faces, there was a second layer of a mixed gray and brown color, as at (3). The concavity at (1) is the depression at the brand.

The vertical section shows the same conditions below the metal line with the case heaviest on (4), the brand side. The case is slightly heavier just below the metal line at (5) than further down on the brick at (6).

A slag nodule (7), adhering to the brick, was pried off without materially affecting the surface of the brick, but a thin layer of oxide and metallic aluminum remained below it. The cap broke off during handling, leaving a thin gray oxide deposit which was scraped off easily without damage to the surface of the brick. The difference in case at (1) and at (2), (4), and (6) may be due to somewhat greater density at (2) and (3) than at (1) and (4). This difference in density might have been caused when the brick was pressed because the brand side was on the bottom against the stationary bottom of the mold and the the other side (2) was against the moving plunger.

Specimen No. 25: An examination of this specimen agrees with the data obtained on specimen No. 9. The piece of slag (1) was easily pulled off with the fingers, after which the surface (2) seemed like a thin skin of tightly adhering metallic aluminum. This slag probably was skim from the surface of the bath which adhered to the brick as the ladle was being drained. The nodules (3) were of the characteristic warty appearance and could be pried off fairly easily, but they generally pulled out the surface of the brick with them. The cap (4) came off during handling, leaving a gray deposit on the surface of the brick; this could be easily scraped off in the form of a powder which resembled the dross from a remelting furnace. The cap, for the most part, is hollow and somewhat spongy underneath. The spongy underside in some cases

FIG. 3.—Specimen No. 40, electrocast tank block.

could be grooved with the finger-nail. Where the cap is solid, it has the characteristic dull gray, metallic luster and hardness of the slag on other specimens; the top surface is fairly rough.

Specimen No. 40, Electrocast Tank Block (Fig. 3)

The original surface of brick above the metal line (1) is shown with a thin skin of aluminum over it. Fracture (2) shows a dark gray surface with metallic luster. The area (2) on the top section registers with the area (2) on the bottom section when the pieces are fitted together.

An unimpregnated portion of the brick (3) is a dirty, brown-violet color; the dark streak between the two sections marked (3) and above the top (3) is shadow, caused by the surface which lies in a different plane than at (3).

The impregnated portion of the brick (4) on the top section registers with area (4) on the bottom section.

Section (5) is the same as (3).

The surface (6) on which the top piece rests was the top of the specimen during the test. The bottom of the specimen during the test is on the bottom piece on the side away from the camera, the bottom corner being at (7). The lower right-hand corner of the bottom piece (8) shows to some extent how this specimen floated and swelled up, although the plane of fracture is not normal with the axis of the specimen.

Specimen No. 2, High-Grade Silicon Carbide (Fig. 4)

Before Fracture: Section (1) is a thin layer of tightly adhering metal. The top looks as if it were covered with barnacles which even extend down along the side of the brick; these barnacles or nodules of slag are bonded right into the brick.

After Fracture: The transverse fracture, about $3^1/_2$ inches from the bottom of the brick, shows impregnation complete except for core (1). This core seems to extend to the bottom surface, but this is only a lighting effect; the core actually is only about $^1/_4$ inches thick and $2^1/_4$ inches long. The vertical fracture shows how the slag from the cap and on the sides of the specimen is intimately bonded into the brick.

At the time of this examination, the edges of the corners of this brick were rapidly being reduced to a powder, which could be easily rubbed off and pulverized with the fingers. The silicon carbide grains apparently are still firm and hard, but the bond has been reduced to a powder. (This condition has been noted on all silicon carbide brick which have been subjected to attack by molten aluminum.) At (2) and (3) on the vertical fracture, there is an apparent difference in color; the difference, however, is due to the fact that the surface at (3) is an angle of the surface at (2), and the lighting in the photograph therefore is different.

Specimen No. 34, Low-Grade Silicon Carbide (Fig. 4)

Before Fracture: A white powdery substance (1) adheres to the surface of the brick; (2) is a thin film of metallic aluminum; and (3) is a film of metallic aluminum with a blackened surface; this film adheres tightly in each case.

A white, hard calcareous-like deposit (4) appears just above the metal line; the slag below (4) may be pried off, but the surface of the brick is also removed.

The original surface of the brick (5) is a dirty violet color; the surface at (6) appears to be glazed and is a deeper violet color; and at (7) the surface seems to be almost the original color, gray with a tan tinge.

After Fracture: The transverse fracture shows penetration of varying depths all around the brick. The core (1) is gray with a slight pink cast. The impregnated area shows several layers (2) on the outside; it is dark gray with a lighter gray layer (3); there is a darker layer at (4); and a dark gray line (5). The transverse fracture (1) was 3 to $3^3/_4$ inches below the bath level; toward the bottom of the brick, the depth of penetration or case decreased to a relatively thin layer all around the brick.

On the vertical fracture, the metal line was at (6–6), but immediately above this line there was no impregnation. Below this line, the depth of case increased to a maximum at about $1^3/_4$ inches below the metal line.

A piece of the top of the brick (7) appears on top of the piece showing the vertical fracture; the aluminum cap has slagged into the top surface of the brick and has resulted in a depth of penetration of $^1/_4$ inch (8).

At the time of this inspection, the bond showed no signs of disintegration in the impregnated portions of this brick; the specimen of the same kind of brick from the first run of test No. 2, however, shows a disintegration of the bond similar to but less than that for specimen No. 2.

Specimen No. 41, Fused Alumina Brick (Fig. 4)

Before Fracture: The metal line is at (1–1); impregnation progressed upward, apparently by capillary attraction, to (2); (3) is a white calcareous-like deposit (which has been noted before); (4) is the unaffected portion of the brick with its original color; (5) is the area with practically no adherent metal or skin; (6) is the same as (5) except that the surface is darker and between the levels (1–1) and (2–2) the skim and dross adhere tightly; and the cap (7) is bonded directly to the brick.

After Fracture: The areas (1) are covered with metallic aluminum which indicates that the specimen was cracked before it was removed from the ladle. This fracture occurred at (8) on the specimen before fracture. These cracks apparently extended in only as far as the specimen had been impregnated. The characteristic black material (2) occurs at the boundary of the unaffected and impregnated portions of the brick.

The vertical fracture (4) is shown in two pieces, one above and one directly below the wooden block against which the paper numbers rest. Actually, these two pieces fit together. The fracture between these pieces occurred at the boundary between the affected and the unaffected portions of the specimen, although a small amount of unaffected material appears at (3); the metal line is at (6).

Areas (4) and (5) are impregnated, but the structure at (4) is a little more dense and darker than (5); the original grain of the brick (4) also seems to be more nearly obliterated than at (5). At (7), which is really a part of (5), the light color is caused by the luster of the fracture at this point, but this luster does not occur at other portions of the brick and its cause is unknown.

At (8) is the familiar black substance mixed in with the rest of the material; (10) is a foreign piece of brick used to hold the specimen upright for photographing. The bot-

tom of the specimen between (8) and (10) matches with the transverse fracture shown at the bottom.

Area (11) is impregnated by the cap on top of the brick. The fracture is a dull dark gray, very dense; the unaffected portion of the brick (12) is the light buff of the original brick. The difference in color is very distinct in the actual specimen. In fracturing this brick, the unaffected portion (12) broke away from the affected portion (5). Then, in trying to obtain a vertical fracture of the top unaffected portion, the cap and impregnated section of the brick immediately below it on the other half of the top than that shown fractured at the boundary between the affected portion and the unaffected portion. This is a characteristic occurrence, and there seems to be a natural cleavage surface between an impregnated and unaffected portion of a specimen.

Specimen No. 32, Fused Alumina Brick (Fig. 4)

Before Fracture: (1) is a thin but rough skim of aluminum; (2) is the same except that the surface is darker; and the characteristic calcareous-like deposit (3) is on the surface of the slag.

The metal line was at (4–4′) and, when the brick was fractured, the slag at (4) broke off and pulled the surface of the brick with it, showing that it was intimately bonded with the brick.

The metal cap did not adhere to the brick (5), and when it was broken off in handling, it left the smooth, approximately unaffected portion of the brick.

After Fracture: The transverse fracture (1) at the bottom shows an almost uniform appearance over the entire surface; the color is a little darker at (1), but it is mottled with small light areas, similar to (2).

There seems to be a small black core (3) somewhat like the black line commonly found at the boundary of the impregnated and unaffected portions of the brick.

The vertical fracture (4) represents an unaffected portion of the brick which occurs in one corner and is continuous with the area (5) on the photograph of the whole specimen; (5) has the same appearance as (2).

The small dark spots scattered over the face of both fractures seem to be individual grains which are affected in a different manner from the rest of the structure. The adherenceof the skim and dross was not very bad. The appearance of this crystal alumina brick was superior to the other crystal alumina specimens (4) and (3). There was no appreciable tendency for the unaffected portion (4) to crack away from the affected portion (5) when the corner was intentionally struck with a hammer.

FIG. 4.—Specimen No. 2, high-grade silicon carbide, before and after fracture; specimen No. 34, low-grade silicon carbide, before and after fracture; specimen No. 41, fused alumina brick, before and after fracture; specimen No. 32, fused alumina brick, before and after fracture.

Specimen No. 8, Steam-Pressed Missouri Clay (Fig. 5)

On the transverse section, (1) represents the core which is unaffected except that the color has changed to a dark, violet-gray with some light-colored grains throughout the mass; (2) is representative of the character of the material on the outside of the brick on both $4^1/_2$-inch faces. It is a dull, dark gray.

The next layer (3) is a lighter gray and has a somewhat more metallic luster. There is none of the material (2) on the $2^1/_2$-inch face side of the fracture; between (3) and (1) is an almost black material.

At (4), there is a spot of this almost black material and at (5) another concentration of the same material.

An area (6) looks black, but this is because the fracture follows this black layer for a short distance.

In a vertical section, material at (7) is the same as (2), and the material at (8) is like (3); (9) is a nonaffected portion except for the discoloration. Slag adherence at the metal line is visible at (10).

A very thin but tightly adhering skin of metallic aluminum occurs at (11); (12) is the same except that the surface of the aluminum is black.

Specimen No. 12, Steam-Pressed Missouri Clay (Fig. 5)

An area on the surface of the brick (1) is apparently unaffected; (2) is a cal-

careous-like incrustation. The cap is bonded to the brick. Some cracks (3) developed during the test. The cap on top, which has a warty appearance, extends down to the side of the brick at (4). When it is fractured, this material (4) looks like material (2) on specimen No. 8. Dross and skim adhere badly in some places, whereas at other places there is a very thin skin on the brick; at and above the metal line the appearance is very bad.

Specimen No. 5, Steam-Pressed Mullite (Fig. 2)

The impregnated portion of this brick varies in appearance. The material seems to be dense at (1), but the adjacent layer (2) seems to be more open and permeated with a black substance. A discontinuous black line may be seen at the boundary of the unimpregnated and impregnated layer. Th unimpregnated core (3) shows merely a change in color from a buff to a pinkish gray. This fracture was $4^1/_2$ to 6 inches below the bath level. The vertical section shows about a $^3/_{32}$-inch depth of case from the cap (4). The location of the metal line is shown by the slag adhering at (5). The depth of impregnation was not materially greater at the metal line than elsewhere; impregnation progressed above the metal line as at (6), apparently by capillary attraction. The fracture of the dense slag adhering to the brick is (7); (8) is a thin metallic and closely adhering layer of aluminum; the roughness at (9) is caused by the anchoring cement.

Specimen No. 20, Steam-Pressed Mullite (Fig. 2)

The cracks, apparent in this specimen, developed after the brick were removed from the ladle and undoubtedly were due to a difference in expansion of the unaffected core and the impregnated part of the brick. The crack at (1) is at the boundary between the unaffected portion (2) and the impregnated portion. In specimens No. 5 and No. 20, there is a marked tendency for cleavage to take place at the boundary between the impregnated and the unaffected portions. The light-colored area at (3) is a very thin but tightly adhering layer of metallic aluminum. The dark area (4) is a very thin but tightly adherent layer of aluminum that is darkened on the surface.

A hard white calcareous-like deposit on the brick (5) is very hard and difficult to chip off. The cap on top is bonded directly to the brick as is also the slag at the metal line.

Specimen No. 18, Power-Pressed Pennsylvania Clay (Fig. 5)

This brick fractured so that transverse and vertical fractures were obtained in the one piece. From (1–1′) to (2–2′), the surface is a transverse fracture; the fracture is vertical above (1–1′).

Except for discoloration to a dark violet portion of the brick, (3) is unaffected. The metal line (4) shows clearly the lesser tendency for impregnation below the metal line.

The original grain structure at (5) is not entirely elimi-

FIG. 5.—Specimens Nos. 8 and 12, steam-pressed Missouri clay; Nos. 18 and 37, power-pressed Pennsylvania clay; Nos. 27 and 33, hand-made Pennsylvania clay.

nated, but at (6) it is eliminated, and the structure is dense and hard.

The line at (7) shows the boundary between the areas impregnated above from the cap on top of the brick and that impregnated below by capillary attraction.

The structure at (6) and (8) has the same appearance even though the boundary line between them is distinct.

The small area (9) is slightly different and is more like (5) below. There is some indication of an additional band at (10) between areas (5) and (6). The original surface of the brick, covered with a thin skin of aluminum, dark in some cases and light in others, shows at (11) and (12).

Specimen No. 37, Power-Pressed Pennsylvania Clay (Fig. 5)

The metal line is at (1), and the slag and dross below this at (2) and (3) apparently stuck to the brick as the metal level fell when the ladle was drained.

The calcareous-like deposit at (4) occurred on top of the remains of the strip of metal which was placed on top of the brick. Some of the cracks below the metal line which appear distinctly show metallic aluminum but others do not, indicating that some occurred before the ladle was drained and others during cooling after the metal was drained. Slag adherence below the metal line is not bad, although a thin skin of darkened metal appears over some of the surfaces; over other surfaces there seems to be merely a black coating which is easily scraped off. The slag appearance is bad at and above the metal line.

Specimen No. 27, Hand-Made Pennsylvania Clay (Fig. 5)

The light areas show where the brick was fractured for examination; the dark areas are surfaces formed by cracks which occurred during the test. Before this brick was fractured, the appearance was much like specimen No. 33, and a multitude of large and small cracks may be clearly distinguished.

Specimen No. 33, Hand-Made Pennsylvania Clay (Fig. 5)

This brick not only has cracked, but there seems to have been sufficient growth within the brick to force out the sides; the overhanging projection (1) is not just slag, but the whole face of the brick has been pushed out and up.

This disintegration is most severe at the metal line. At the bottom of the brick, impregnation has proceeded only to a depth of about $^{3}/_{32}$ inch; at (2), where the corner was fractured off, the original grain is unaffected.

Specimen No. 14, Machine-Made Silica Brick (Fig. 2)

This entire brick was impregnated, but it had a rather mottled appearance, possibly due to the rather large grains of silicon. There seem to be several layers, which are more readily distinguished on the photograph than on the specimen itself (this is also true of the light-colored core at (1) and the black seam within this core). The cap on the top of the brick impregnated at some points and not at others, but there was a considerable portion of unaffected brick between the portion impregnated from the cap and that impregnated from below; this is shown at (3), where part of the top of the brick has been broken off.

The boundary surface between the unaffected portion and the portion affected from the bottom is shown at (2); a few small specks which show up as light spots at (2) are unaffected portions of the brick; the darker area is the affected portion.

Specimen No. 30, Machine-Made Silica Brick (Fig. 2)

The entire top portion of this brick is covered with a warty formation as at (1), with here and there, as at (2), a small area of the original surface of the brick showing through. At point (2), the brick is covered with a light gray deposit. The brick does not show any cracks, but the adherence of metal and dross is bad.

IV. Summary

A study of these brick indicates clearly that, for any class of brick, the penetration or impregnation is a function of the density of the brick. A handmade brick, naturally more porous, is more readily impregnated with aluminum than a power-pressed or a steam-pressed brick. The impregnated layer is extremely hard in all cases. Hardness tests were made with the point of a knife used as an awl. The general tendency seems to be for greater impregnation from contact with a mixture of metallic aluminum and oxide on top of the brick than in the case of metal alone at the bottom of the brick, although this is not true in every instance. The impregnation does not seem any more severe at the metal line than at the top. A layer of white powdery material generally forms at the metal line and often below, which may retard impregnation. It is possible that contact with air (oxygen) may influence the action and account for the greater impregnation on the tops of the brick.

The disintegration and swelling of many of the brick has been explained sometimes on the basis of a possible thermit reaction between the molten aluminum and particles of iron oxide scattered throughout the brick. As the molten aluminum penetrates the brick and comes in contact with particles of iron oxide, which are present in many brick as small grains or flakes, the thermit reaction could take place, generating temperatures within the brick which apparently are in excess of the vitrification temperature. Some brick removed from the bottoms of open-hearth furnaces actually show evidence of having been subjected to extremely high temperatures.

In many cases, the structure of the brick directly adjacent to the impregnated layer has a tendency to be slightly softer than the remainder of the brick; this is more noticeable at the top than at the bottom. There is a calcareous-appearing layer or line at the point of impregnation in nearly all of the brick which is extremely hard and somewhat lighter in color than the adjacent material.

A furnace bottom will spall off occasionally in quite large-sized areas, and the brick will float up. This condition continues until the hearth requires replacing. It is difficult to explain why this should be true of one bottom and not of another. The manufacturers have been unable to offer a clue as to the reason for this condition, but the writer believes that a study of the results of this test will give the answer. If the impregnated layer of brick should swell and crack (as shown in some of these pictures), it is not strange that the hearth brick should fail. It has been general knowledge that an open, porous brick will not resist abrasion as well as a hard dense brick but that it does withstand rapid

temperature changes better than a dense brick. It was not known, however, that a porous brick would be impregnated with aluminum so much more readily and that therefore it should not be used below the metal line.

Not all brick failures are caused by the brick themselves; faulty bricklaying can be the cause of much trouble. Undoubtedly the brick manufacturers have been unjustly blamed oftentimes for failures of this kind.

Although all of the shortcomings of refractory brick used in melting aluminum cannot be explained by the results of this test, it does supplement the properties of brick, such as resistance to abrasion and to spalling, coefficient of expansion, etc., that are generally known, and it goes a long way toward clearing up some of the mysterious brick failures which have been occurring from time to time. It has also been valuable as a guide in the kind of brick to use.

No data have been given of which brick most nearly meet the requirements for open-hearth melting of aluminum, and the only rating given has been on a basis of the gain in weight. This is but one of many properties which must be judged in arriving at the answer. A brick may not gain much in weight, but it may crack badly; or it may be satisfactory physically but react chemically, thereby putting impurities in the aluminum, which of course is undesirable.

The writer hopes that this test will be an inspiration to manufacturers of refractories to continue to study scientifically and practically the effects of molten aluminum on various refractories, so that the users may enjoy the benefits of better and cheaper furnace linings.

Aluminum Company of America
2210 Harvard Avenue
Cleveland, Ohio

Discussion

Question: At what temperature does the thermit reaction within the brick in the hearth take place?

Answer: I have no means of knowing the temperature at which this reaction takes place, but I do know that the temperature of the brick never exceeds 1400° or 1500°F., which is much below the temperature necessary to start the thermit reaction when iron oxide and aluminum are used regularly.

Question: From data obtained during this test, what type of brick has proved to be most satisfactory for your use in aluminum smelting?

Answer: It was decided that the most economical brick to use for melting aluminum is a hard-pressed, first-quality fire brick or possibly one in which the alumina is slightly in excess of that found in the ordinary grade of fire brick.

Question: Has magnesite brick been used as a hearth material in the aluminum melting furnaces?

Answer: Small sections of a hearth have been laid in magnesite brick for test purposes, but to the best of my knowledge no complete magnesite hearth has ever been installed.

Question: What is the status of silicon carbide crucibles for melting in the aluminum industries? Is much aluminum being melted in this type of crucible?

Answer: For ordinary foundry work, the cast-iron pot is still the most widely used and it is the favorite medium of melting. Crucibles, however, are being used in increasing numbers, and the time may come when crucible melting will replace to a large extent the iron pot. This is especially true when higher purity alloys are being handled. Some tests, which have been run, would indicate that crucible costs are equal to or slightly lower than iron-pot costs when silicon carbide crucibles are used.

Question: Are brick with a low iron content essential in aluminum melting?

Answer: A hard-pressed brick in which the iron particles are widely distributed seems to have no injurious effect on the melt. The iron pickup on this test was not nearly so great as the silicon, which would indicate that the silica might be more detrimental than the iron oxide.

STUDY OF THE RECRYSTALLIZATION OF MAGNESIA*

By H. G. Schurecht and V. D. Fréchette

Abstract

X-ray studies show that lightly calcined magnesite is cryptocrystalline, with an atomic structure identical with that of periclase and fused magnesia.

I. Introduction

High-magnesia refractories must be fired at high temperatures to convert all of the free magnesia to the inert form, periclase. Although lightly calcined magnesite is a light, fluffy powder, chemically active and readily slaked by atmospheric moisture, it may be converted by heat treatment to a coarsely crystalline material which is volume stable, almost inert chemically, and resistant to hydration.

The low-temperature calcination of magnesium nitrate, magnesium carbonate, or magnesium hydroxide, or the burning of metallic magnesium in oxygen yields a product which Mellor,[1] Searle,[2] and the International Critical Tables have called "amorphous magnesia" or "alpha-magnesia." Mellor describes it as an amorphous, voluminous powder of low specific gravity. The specific gravity has been given values ranging from 2.3 to 3.4. It is readily attacked by acids, and it reacts speedily with water to form the hydroxide.

Periclase is a colorless-to-grayish or dark green mineral of the formula MgO, and it crystallizes in the isometric system in cubes and octahedrons with perfect cubic and less distinct octahedral cleavages. It is isotropic, with an index of refraction for the D line of the sodium spectrum of 1.73, and its hardness is that of orthoclase, viz., 6 on Mohs' scale. Its specific gravity is about 3.7.

Bragg[3] reports the atomic structure of periclase to be of the sodium chloride type with a unit cube containing four MgO of side 4.22 A.

Periclase crystallizes out when magnesia is melted and cooled, but it may be formed at temperatures far below the melting point. Various investigators, measuring the decrease in rate of hydration, increase in specific gravity and hardness, and the change in heat of solution of lightly calcined magnesite upon heat treatment, have assigned values as low as 800°C. for the minimum temperature of the transformation.

The effect of impurities on the rate of transformation is important in commercial dead burning of magnesite. The effect of Fe_2O_3 as a catalyzer in the process has been discussed by McDowell[4] and is well known in connection with the manufacture of magnesite brick. Kondo[5] states that silica and alumina also favor the transformation. Hydrochloric acid is a particularly effective catalyst, and periclase has been formed in large crystals by a number of workers by decomposing $MgCl_2$ at a red heat, by the action of HCl on red-hot magnesia, or by the action of steam on red-hot $MgCl_2$.

The purpose of the present investigation was to study the nature of the transformation of magnesia to periclase and to measure the lowest temperature at which the change will take place.

II. The Investigation

Three commercial crude magnesites, from Washington, California, and Greece, were fired (1) for four hours at temperatures from 800° to 1400°C. at 100° intervals and (2) for fourteen hours at 750°C., using a small furnace of the Globar type. The c.p. MgO* was fired with the others at 1000°C. and higher.

A small sample of Mallinckrodt c.p. $MgCO_3$ was heated in a vacuum furnace at 425°C. at a pressure of 8 mm. of Hg for three hours.

(1) Microscopic Examination

In all of the materials fired to 1300° and 1400°C., the crystals of periclase could be clearly distinguished. Below this, however, it was impossible to resolve crystals, even with the oil-immersion objective. Both transmitted and reflected illumination were tried without success.

(2) X-Ray Analysis

The powder diffraction patterns of the samples taken with the circular camera (using a wedge-formed sample) were compared with patterns of crude magnesites, fused magnesia, a natural periclase crystal, and an artificial crystal from an electric steel furnace.

III. Discussion of Results

Examination of the X-ray diffraction patterns showed that the magnesites fired at 750°C. no longer have the

* Presented at the Forty-First Annual Meeting, American Ceramic Society, Chicago, Ill., April 19, 1939 (Refractories Division). Received November 22, 1939.

Based on a thesis submitted by Van Derck Fréchette in partial fulfillment of the requirements for the degree of B.S. in general ceramic technology and engineering, New York State College of Ceramics, Alfred, N. Y., August, 1938.

[1] J. W. Mellor, Comprehensive Treatise on Inorganic and Theoretical Chemistry, Vol. IV, p. 280. Longmans, Green & Co., Ltd., London, 1929; *Ceram. Abs.*, **8** [5] 373 (1929).

[2] A. B. Searle, Chemistry and Physics of Clays, 2d ed. Ernest Benn, Ltd., London, 1933; *Ceram. Abs.*, **13** [2] 50 (1934).

[3] W. L. Bragg, Atomic Structure of Minerals, p. 92. Cornell University Press, Ithaca, N. Y., 1937; *Ceram. Abs.* **17** [6] 231 (1938).

[4] J. S. McDowell and R. M. Howe, "Magnesite Refractories," *Jour. Amer. Ceram. Soc.*, **3** [3] 185–246 (1920).

[5] S. Kondo, T. Sueno, and H. Yoshida, "Magnesite Refractories: I, Microstructure of South Manchurian Magnesites Fired at Different Temperatures," *Jour. Jap. Ceram. Assn.*, **40** [475] 422–36 (1932); *Ceram. Abs.*, **12** [4] 159 (1933).

* From the J. T. Baker Chemical Co., prepared from the carbonate by calcination at about 960°C.

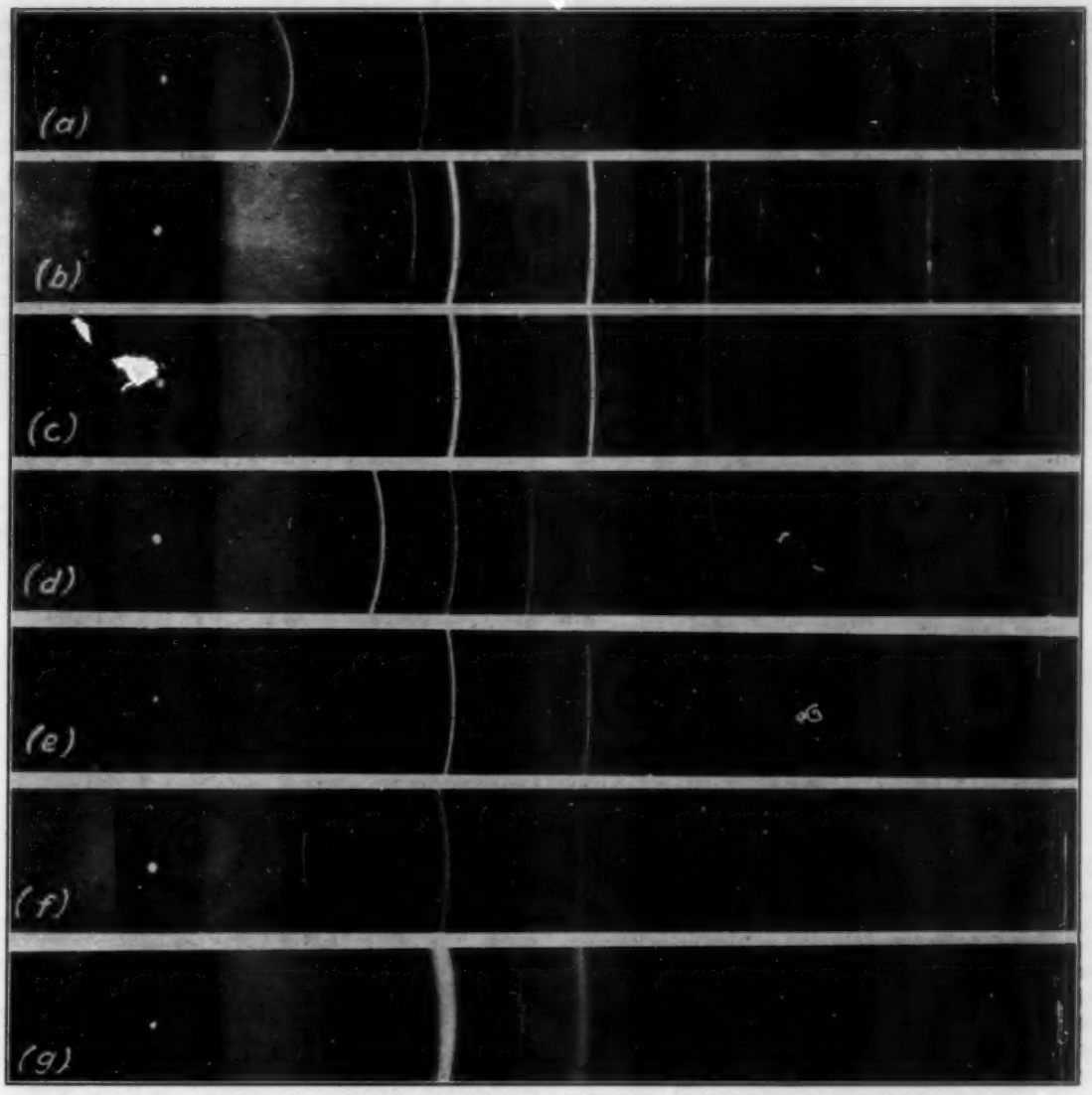

FIG. 1.—(*a*) Brucite ($Mg(OH)_2$); (*b*) fused magnesia; (*c*) artificial periclase crystal; (*d*) crude Grecian magnesite; (*e*) c.p. MgO fired 4 hours to 1400°C.; (*f*) Grecian magnesite fired 14 hours to 750°C.; (*g*) c.p. $MgCO_3$ fired *in vacuo* 3 hours at 425°C.

atomic structure of magnesite ($MgCO_3$) but clear sharp lines, whose positions and intensities are characteristic of periclase. A slight broadening of the lines indicates the particle size to be slightly less than 10^{-6} cm. in diameter.

This is shown for Grecian magnesite in Fig. 1, (*a*) through (*g*), by the contrast between the pattern of that material (*f*) fired at 750°C. with those of crude Grecian magnesite (*d*) and brucite ($Mg(OH)_2$) (*a*), and by the similarity of the patterns of the fired material and those of the artificial crystal (*c*), fused magnesia (*b*), and the c.p. MgO fired at 1400°C. (*e*).

Similar results were obtained for the other materials tested.

The diffraction pattern of the c.p. $MgCO_3$ calcined at 425°C. *in vacuo* (Fig. 1 (*g*)) shows the conversion of the carbonate to MgO, whose atomic structure is seen to be that of periclase. The marked broadening of the diffraction lines indicates very fine particle size, considerably below 10^{-6} cm. in diameter.

The dead burning of magnesite involves simply a recrystallization of tiny periclase crystals with the formation of much larger crystals.†

This conclusion is entirely consistent with the properties which have been reported for the two materials. The increase in particle size of lightly calcined magnesite above the colloidal range would be expected to involve a decreased chemical activity and heat of

† This crystallization may take place through the vapor phase by the formation of intermediate compounds with impurities or by solution and recrystallization.

solution, and the shrinkage of minute pores accounts for the increased hardness and specific gravity.

IV. Summary

(1) Because lightly calcined magnesite showed an X-ray diffraction pattern of clear sharp lines, it is evidently not amorphous but cryptocrystalline, with a particle size in the colloidal range.

(2) Because the diffraction pattern of lightly calcined magnesite is identical with the patterns of fused magnesia and of artificial and natural periclase crystals, the atomic structure of all these materials is identical.

(3) In the materials tested, the difference between lightly calcined magnesite and periclase is simply one of particle size, and the transformation by heat treatment effects neither a change from an amorphous to a crystalline form nor an inversion from one crystalline form to another but merely a recrystallization, involving the growth of large crystals from smaller ones.

Acknowledgment

The writers wish to express their sincere appreciation to J. F. McMahon of the Ceramic Experiment Station for his unfailing interest and helpful suggestions; to the Harbison-Walker Refractories Company, F. E. Schundler & Company, General Magnesite and Magnesia Company, Hammill and Gillespie, and the Electro Refractories and Alloys Corporation for their kindness in submitting samples for use in this investigation; and to Canadian Refractories, Limited, for the chemical analyses of the samples.

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REVIEW OF FOUR YEARS OF RESEARCH ON REFRACTORY PROPERTIES OF PACIFIC NORTHWEST OLIVINE*

By Hewitt Wilson and Kenneth G. Skinner†

Abstract

This discussion covers a study of the refractory properties of the olivine from two large deposits in Washington. The research was devoted mainly to (*a*) physical, chemical, and mineralogical properties, (*b*) effect of chemical additions, (*c*) development of the densest and most refractory body, (*d*) manufacture of brick, (*e*) comparison of these brick in P.C.E., spalling, load test, absorption, and resistance to basic slags with other brick, and (*f*) local use of olivine as a foundry sand.

I. Introduction

During the first three years of the investigation, the fundamental properties of olivine from local deposits were studied, including chemical composition, fusion point, and changes in weight and volume upon heating. The high quality of Pacific Northwest olivine was established by comparison with other olivines, and the next step was to develop a use for the material as a refractory. The utilization of olivine as a blasting or as a foundry sand was of secondary interest. Standard-size, dry-pressed refractories have been made and compared with commercial basic refractories.

II. Pacific Northwest Olivine

The two largest deposits of olivine in Washington are found in the Twin Sisters Mountain region, about 90 miles northeast of Seattle, and on Cypress Island, about 80 miles northwest of Seattle. An average chemical analysis of a number of Pacific Northwest olivines showed 47% MgO, 40% SiO_2, 11% Fe_2O_3, 1% Al_2O_3, and 1% ignition loss.

(1) Cypress Island Deposit

Olivine forms a symmetrical dome called Olivine Hill on the southeast corner of Cypress Island. The hill, which is principally dunite, rises to an elevation of about 600 feet at the center and covers an area of about one-half by two-thirds of a mile. The importance of this deposit lies in its large tonnage of refractory olivine and in its location at tidewater for boat shipment.

The olivine is vitreous and ranges in color from light and dark greens to tans and reds, depending on the weathering and oxidation. Some of the deposit has a "sugary" or grainy appearance, and most of the more refractory material contains specks at chromite.

(2) Twin Sisters Mountain Region

Large deposits of dunite have been reported in the Twin Sisters Mountain region, about ten miles southwest of Mount Baker. This area is quite rugged and accessible only by mountain trails. The dunite outcrops in an area about 11 miles long and more than 4 miles wide and at elevations between 3000 and 6000 feet above sea level. A few chromite outcrops are visible at the higher altitudes as scattered zones or bands of black or brownish streaks against the yellow-brown dunite.

The dunite is fractured in two directions; the major fracturing follows the axis of the Twin Sisters Range, and the other is approximately at right angles to it. Al-

* Presented at the Golden Gate Meeting, American Ceramic Society, San Francisco, Calif., August 10, 1939. Received August 14, 1939.

Work on manuscript completed July, 1939. This report gives the results of work done under a cooperative agreement between the Northwest Experiment Station, Dept. of Int., U. S. Bureau of Mines, and the University of Washington, Seattle, Wash. Published by permission of the Director, Bureau of Mines (not subject to copyright).

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though there are no visible bedding planes, the deposits are fractured and weathered, causing steep bluffs and cliffs. Enormous quantities of exposed vitreous dunite with fusion points above cone 30 are present in the Twin Sisters Mountains region, but there are no transportation facilities at the present time.

III. P.C.E. of Pacific Northwest Olivines

The pyrometric cone equivalent or fusion point of an olivine is the primary index of its value as a refractory raw material. The fusion point, in general, is in inverse proportion to the amount of low-melting material present, such as serpentines and talcs. The P.C.E. of representative olivines from Cypress Island ranged from cones 26 to 35; the Twin Sisters region olivines had fusion points from cones 30 to 36.

Attempts were made to correlate color or other physical properties with the fusion point, but no accurate correlation was found. By plotting the P.C.E. on a triaxial diagram, the corners of which were MgO plus CaO, Fe_2O_3 plus Al_2O_3, and SiO_2, and by drawing iso-P.C.E. lines, the general composition areas, with few exceptions, were found in which short fusion ranges existed (see Fig. 1).

(1) P.C.E. of Olivine Mixed with Other Materials

The effect of the addition of other materials on the fusion points of olivines was determined by adding magnesia, chromite, high-aluminous firebrick, ferric oxide, calcium carbonate, zirconia, and sodium silicate. The results of some of these additions are shown in Fig. 2. It was found advisable to use not more than 1% of sodium silicate as a low-temperature binder, owing to its rapid fluxing action.

The fusion points of mixtures of chromite, magnesia, and olivine were determined, using maximums of 50% of chromite and 50% of magnesia. The P.C.E. range of these mixtures was from cones 34 to 36; the values decreased when the quantity of magnesia was held constant and that of chromite was increased.

IV. Refractory Body

The value of a refractory in copper furnaces, crowns of open-hearth steel furnaces, and cement kilns depends on two major factors, viz., (1) the high-temperature, load-bearing capacity and (2) the resistance to slag erosion. Other factors are thermal conductivity, spalling resistance, and thermal expansion.

The high-temperature, load-bearing capacity depends on the fundamental refractory properties of the raw material as well as on the density and grain structure of the manufactured product. Slag resistance depends on the chemical nature of the material and also on the density of the refractory. A study therefore was made to develop the densest olivine body.

(1) Preparation of a Dense Refractory Body

Four methods are generally used to obtain dense systems of aggregates, viz., (1) the use of high forming pressures, (2) proper lubrication of the grains, (3) particle grading for maximum packing density, and (4) particle packing by vibration or agitation.

The first three of these methods were tried to increase the density of the olivine refractory.

(2) Grain Sizing and Particle Packing

Because five different screen fractions (grain sizes) would be commercially feasible, the theoretical mixture of five sizes giving the maximum density was calculated and found to be, from the coarsest to the finest, 57.6, 24.7, 10.6, 4.6, and 2.0%. Eight screen fractions were made of a crushed olivine, and different combinations of five of the eight fractions were used in the proportion

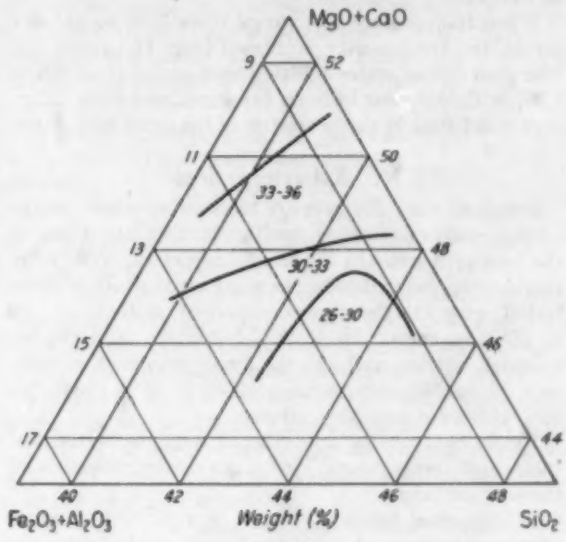

FIG. 1.

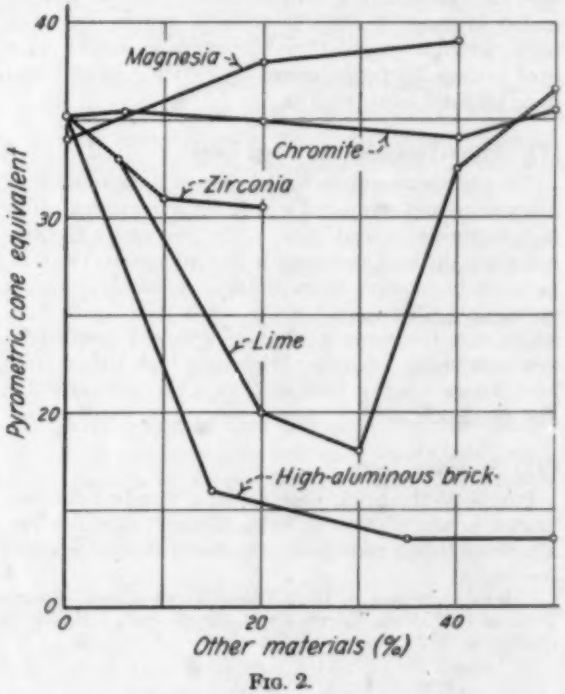

FIG. 2.

previously calculated. The brick, made in a hand dry press, showed that the densest body was obtained when every other screen fraction was used. The lowest porosity of the dry brick was 18.1%.

(3) Effect of Forming Pressures and Quantity of Binding Liquid

To find the effect of forming pressures, a small steel mold was made to press briquettes about 3 by 3 by $1^1/_2$ inches. Using the same compositions and pressures, the amount of binding liquid was varied to find its effect on the density of the body.

When the pressure was varied from 1780 to 4444 lb. per sq. in., the porosity decreased from 17.1 to 13.9%. The gum arabic water solution was varied from 3.5 to 7.5% with the same forming pressures, and little difference was found in the porosities of the dried briquettes.

V. Refractory Brick

Standard-size, dry-pressed brick were made of the olivine, magnesia, and chromite mixtures found to give the best properties in the small briquettes. The compositions considered to be the most satisfactory of those tested were (1) the three-component system, i.e., 10 to 30% magnesia, 10 to 20% chromite, and the remainder, olivine and (2) the two-component system, i.e., 20 to 30% magnesia, and 70 to 80% olivine or 20% chromite and 80% olivine.

Blocks cut from the crude olivine were also tested, but their high-temperature load values were lower than those of the brick.

A 150-pound batch of each of four different compositions was prepared, lubricated, and bonded with 4% of liquid, containing 2% of lignin binder. The batches were then pressed in a commercial dry press at an estimated pressure of 5000 to 6000 lb. per sq. in. The brick, which averaged 10 to 12 pounds in weight, were fired to cone 30 (approximately 3000°F.) in 12 hours in an oil-fired, load-test kiln.

(1) High-Temperature Load Tests

The high-temperature load values of these brick were determined and compared with other refractories. The high-temperature load value is the area under the zero line when the load shrinkage is plotted against the temperature in cones, 4 cones and 4% shrinkage equaling one inch.[1] This value for the brick tested was 8.75, which was the same as that of a tested commercial forsterite brick. Fireclay brick have high-temperature load values ranging from 0.35 to 8.15; chromite 3.8; and magnesite 4.3.

(2) Slagging Tests

Panels of the brick were set in a slag-test furnace, heated to about 2780°F. (about cone 19) in 6 hours, after which 160 pounds of granulated slag, in 4-pound quantities at 20-minute intervals, were blown against the test brick. The erosive and corrosive action of the slag was measured by the volume, weight, and porosity changes in the brick. The slags used were a Portland cement clinker and a slag from a basic open-hearth steel furnace.

These tests indicated that the brick made from Washington olivine underwent less change of volume than the magnesite and that they were equal to the chrome brick. The high-aluminous brick tested reacted with the extremely basic slag and had the greatest loss of volume.

(3) Spalling Tests

Water-dip spalling tests were made by heating one end of the brick to 2500°F. for 1 hour, immersing the hot end in 2 inches of cold running water for 3 minutes, and then allowing it to steam in the air for 5 minutes. This cycle was repeated until 20% of the original weight of the brick had spalled off. The laboratory-prepared brick stood a minimum of two water spalls, whereas the magnesite withstood only one. The average fireclay brick withstood from four to six spalls.

VI. Olivine as a Foundry and Blast Sand

Laboratory and plant tests indicated that olivine could be used locally as a foundry and as a blast sand. The high melting temperature, a hardness similar to that of quartz, no sudden changes in volume due to mineral inversion, and the comparatively low coefficient of expansion of olivine are desirable attributes of a foundry sand. The olivine had a higher fracturing loss than the best grade of blast sand, but it can be used where the cost of such sand is rather high. Foundry tests showed that the ground olivine was satisfactory as a molding sand in brass and iron foundries and possibly for the lightweight steel castings up to 30 pounds.

VII. Summary and Conclusions

The satisfactory behavior of the forsteritic refractories manufactured from Pacific Northwest olivine may be attributed to the high density obtained by grain-size control and to the proper addition of the conversion agents, chromite and magnesia.

The results of this work show that an excellent refractory may be made from Pacific Northwest olivine. The method of manufacture is simple, and the necessary raw materials are plentiful. Economic problems concerning the production and marketing remain to be solved by those interested in the utilization of the industrial minerals of the Pacific Northwest.

Acknowledgment

The writers acknowledge their indebtedness to L. H. Berkelhamer, R. W. Cline, F. L. Goin, G. E. Kravik, and M. K. Blanchard whose theses formed the basis for this summary.

[1] Hewitt Wilson, "High-Temperature Load Fusion Tests of Fire Brick," *Jour. Amer. Ceram. Soc.*, 7 [1] 34–51 (1924); p. 37.

DIFFUSION OF HELIUM THROUGH SEVERAL GLASSES*

By Paul L. Smith and Nelson W. Taylor

Abstract

The rates of diffusion, R, of helium through four glasses of varied composition have been measured as a function of temperature up to and including the "transformation points" of the glasses. Two borosilicates, a lead glass, and a soda glass were studied, and the effect of heat treatment was investigated. A plot of log R vs. $1/T$, in general, proved to be made up partly of a straight line and partly of a curving line at temperatures where the glass became soft enough to relieve strain. The borosilicates showed either no break or only a slight break at the "transformation point," whereas the lead and soda glasses showed more pronounced changes in slope near the "transformation point." The borosilicates showed a shift to higher rates with heat treatment; and the lead glass, a shift to lower rates. It is believed that completely annealed glass would show a linear log R vs. $1/T$ relation over the entire temperature range.

The permeability of the glass to the diffusion of helium at any temperature decreases as the percentage of basic oxides or of cations increases. This may be interpreted in terms of the atomic arrangement in these glasses.

I. Introduction

In view of the results obtained by Taylor and Rast[1] on the rate of diffusion of helium and of hydrogen through Pyrex-brand glass, it seemed desirable to extend the diffusion studies to glasses of other compositions. The purpose of the present investigation was to study the effect of temperature and heat treatment on the diffusion rate of helium in glasses of varied composition. The studies were made over a temperature range wide enough to include the "transformation point." Glasses of widely different composition were chosen to see what general conclusions might be drawn concerning the behavior of these gases in glass.

(1) Historical

In 1900, Villard apparently was the first to observe that silica is permeable to hydrogen. Since that time much work has been done on the diffusion of various gases through fused silica, and studies have also been made on glasses of more complex composition.

The diffusion rates of at least six different gases have been reported in the literature. Mayer[2] measured the rates of O_2, N_2, and A; Williams and Ferguson,[3] H_2, He, air, and N_2; T'Sai and Hogness,[4] A, Ne, and He. In all these studies the glass used was fused silica. Combining the results, the gases studied may be placed in the following order of increasing diffusion rate, viz., A, N_2, O_2, Ne, H_2, and He.

Van Voorhis[5] studied the effect of composition of the glass on the diffusion rate of helium and found that the diffusion rate, in general, increased with increasing acid content and decreased with increasing basic content. Substances, such as PbO and Al_2O_3, had little effect, and fused silica had by far the highest rate.

Urry,[6] who more recently investigated the diffusion of helium through several glasses of various composition, obtained similar results.

The diffusion of helium through crystalline materials has also been measured[7]; in the case of quartz, the diffusion rate appears to be the same whether the crystal is cut parallel or perpendicular to the optic axis, and this rate is approximately one half that of fused silica.

(2) Diffusion Rate and Activation Energy

The diffusion rate for most glasses has been found to be directly proportional to the pressure and to be an exponential function of the temperature. When log R vs. $1/T$ is plotted, wherein R is the diffusion rate and T the absolute temperature, a straight line results if the temperature range is not too great. The activation energy which governs the diffusion process may be computed from the slope of this line. The activation energies for the diffusion through silica of the six gases named follow the inverse order of the rates except that those for H_2 and Ne are about equal.

(3) Mechanism of Gas Diffusion Through Glass

Different mechanisms have been proposed to account for the passage of the gas through glass. It is known

* Received November 27, 1939.
Submitted in partial fulfillment of the requirements for the degree of Doctor of Philosophy, The Pennsylvania State College, 1937.
This study was made while Dr. Smith held a Fellowship granted by the Edward Orton, Jr., Ceramic Foundation.

[1] N. W. Taylor and W. L. Rast, "Diffusion of Helium and Hydrogen Through Pyrex Chemically Resistant Glass," *Jour. Chem. Phys.*, **6** [10] 612–19 (1938).

[2] E. C. Mayer, "Leakage of Gases Through a Quartz Tube," *Phys. Rev.*, **6** [4] 284 (1915).

[3] G. A. Williams and J. B. Ferguson, "Diffusion of Hydrogen and Helium Through Silica Glass and Other Glasses," *Jour. Amer. Chem. Soc.*, **44**, 2160–67 (1922); *Ceram. Abs.*, **2** [2] 14 (1923).

[4] L. S. T'Sai and T. R. Hogness, "Diffusion of Gases Through Fused Quartz," *Jour. Phys. Chem.*, **36** [10] 2595–2600 (1932); *Ceram. Abs.*, **12** [2] 54 (1933).

[5] C. C. Van Voorhis, "Diffusion of Helium Through Several Widely Differing Glasses," *Phys. Rev.*, **23** [5] 557 (1924).

[6] W. D. Urry, "Further Studies in Rare Gases: I, Permeability of Various Glasses to Helium," *Jour. Amer. Chem. Soc.*, **54** [10] 3887–3901 (1932).

[7] E. F. Burton, E. O. Braaten, and J. O. Wilhelm, "Diffusion of Helium Through Quartz in Relation to Temperature," *Can. Jour. Research*, **8** [5] 463 (1933).

that neither the temperature coefficient of the rate nor the comparative rate for gases of different molecular weights can be explained on the basis of simple effusion. Such a mechanism requires that the rate be proportional to the square root of the absolute temperature. The increase with temperature is actually far greater than this.

Alty[8] has suggested that the molecules of the gas enter the glass directly from the gas phase and then diffuse along cracks into the body of the glass according to the Lennard-Jones theory of surface diffusion.[9] On this basis, he derives the formula,

$$\mu = CPe^{-(W_0+E_0)/kT}$$

Wherein μ = diffusion rate.
C = constant.
P = pressure.
k = Boltzmann's constant.
T = temperature (°K.).
$W_0 + E_0$ = activation energy.
W_0 = that part of the activation energy which acts only at the surface of the solid.
E_0 arises from forces of the nature of Van der Waal forces.

In deriving this formula, it was assumed that $E_0 << kT$, so that the linear relation would not be expected to hold at low temperatures.

Barrer[10] used Alty's results, but, with a slight modification in the assumptions, he derived a similar formula and concluded that the relation should be linear even at low temperatures.

II. Experimental

The four glasses chosen for the present study were available commercially in tube form and provided a wide range in composition and softening point.

The "transformation points," T_g, and the softening points, T_s, of the various glasses were determined in the usual manner by thermal-expansion measurements. Determinations of the rates of diffusion were made over a wide range of temperature, the lower limit being determined by the point where the amount of diffusion was barely measurable in a reasonable time and the upper limit by the softening of the glass. In most cases, measurements were taken at least twenty degrees above the T_g of the glass.

(1) Specimens

Three of the glasses used in these tests were obtained as tubes,* the fourth was a Pyrex-brand chemically resistant laboratory glass in the form of a small test tube.

[8] T. Alty, "Diffusion of Monatomic Gases Through Fused Silica," *Phil. Mag.*, **15** [7] 1035–48 (1933); *Ceram. Abs.*, **13** [6] 163 (1934).

[9] J. E. Lennard-Jones, "Processes of Adsorption and Diffusion on Solid Surfaces," *Trans. Faraday Soc.*, **28** [3] 333 (1932).

[10] R. M. Barrer, "Mechanism of Activated Diffusion Through Silica Glasses," *Jour. Chem. Soc.* [London], pp. 378–86 (April, 1934); *Ceram. Abs.*, **13** [10] 254 (1934).

* Samples obtained from Corning Glass Works, Corning, N.Y., through the courtesy of W. C. Taylor, chief chemist.

The chemical analyses of the glasses are given in Table I.

TABLE I

CHEMICAL ANALYSES OF GLASSES USED FOR DIFFUSION SAMPLES

	Glass sample (weight %)			
	A	B	C	Pyrex-brand
SiO_2	62.0	73.0	61.0	80.75
PbO	23.0			
K_2O	6.5	0.5		0.10
Na_2O	7.5	17.0	8.0	4.10
Al_2O_3	1.0	1.0	2.5	2.20
CaO		5.0		0.3
MgO		3.5		
B_2O_3			29.0	12.0
As_2O_3				0.40
	100.0	100.0	100.5	99.85

The helium† contained nitrogen and hydrocarbons as impurities. The hydrocarbons were removed by adsorption in activated charcoal at liquid air temperatures. The total helium content was about 99%.

(2) Apparatus

The thermal-expansion measurements were made by using a fused quartz tube, a fused quartz rod, and a dial gauge with scale divisions of 10^{-4} inch. This apparatus was placed in a Nichrome wire-wound furnace and heated at the rate of 3°C. per minute. Specimens for these measurements were pieces of tubing, approximately 0.2 inch in diameter and 2.5 inches long.

The apparatus for making the diffusion measurements consisted of a vacuum system and furnace with temperature control. The vacuum system is shown in Fig. 1. The mercury-seal type stopcocks are designated by the letter S with subscript. A McLeod gauge was attached at M, with the scale reading from 0.001 to 170 microns. A manometer of the open-arm type attached at P was used to read the difference between the helium and the atmospheric pressures. The atmospheric pressure was read with a sensitive aneroid barometer, which was calibrated before and during use with a mercury barometer.

A known volume, V, could be cut into or out of the system by a stopcock and was used to find the volume of that part of the system into which the helium diffused

† Samples from the Helium Division, Girdler Corporation, Dexter, Kans.

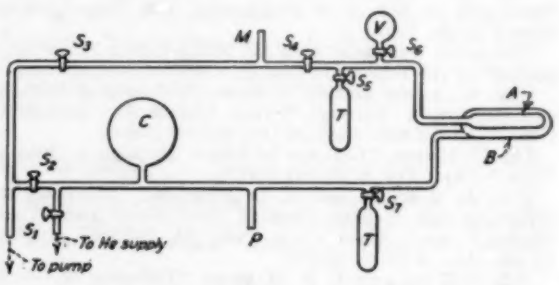

FIG. 1.—Vaccum apparatus for diffusion measurements

during a run. A large flask, C, was used to add volume capacity to the system. Traps are shown at T, and the sample is designated by A.

For maintaining the vacuum, a mercury diffusion pump with a Cenco Hyvac fore-pump was used.

The Pyrex-brand samples were sealed directly to the vacuum system, which was also Pyrex-brand glass. In the case of the soft glass samples, because a direct glass connection could not be made inside the furnace, seals were made outside with Cenco Para-rubber tape. The leak rate with this type of seal was found to be constant at 1 micron per hour.

III. Method of Using Apparatus

The furnace was adjusted until the sample was at the same temperature (± 0.25°) throughout its length as indicated by three thermocouples. The McLeod gauge was then read to make certain that the system was tight, stopcock S_8 was closed, and pressure readings on the McLeod gauge were taken at definite intervals. Readings of room and furnace temperatures, atmospheric pressure, and pressure, P, indicated by the manometer, were also taken throughout the run. Ordinarily 20 to 120 minutes sufficed to complete a single determination.

From the McLeod gauge-time readings, the rate, dp/dt, in microns per minute may be obtained from which $(dp/dt)_{760}$ mm. may be calculated, using the relation that the rate is proportional to the pressure on the high pressure side of the diffuser, i.e.,

$$(dp/dt)_{760} = \frac{760}{P}(dp/dt).$$

This relation has been verified for helium through Pyrex-brand glass by Taylor and Rast.[1] Part of the gas on the gauge side of the diffusing system is at room temperature and part at furnace temperature, because only the diffusing sample is in the furnace.

Therefore $$pv = \frac{m}{M}RT.$$

$$\frac{dm}{dt} = \frac{M}{R}\left(\frac{V_f}{T_f} + \frac{V_r}{T_r}\right)\left(\frac{dp}{dt}\right)_{760}.$$

Where T_f and T_r = furnace and room temperatures, respectively.
V_r = volume of that part of system at room temperature.
V_f = volume of that part at furnace temperature.
M = molecular weight of helium (4.002).
R = gas constant (8.316×10^7 ergs/degree).

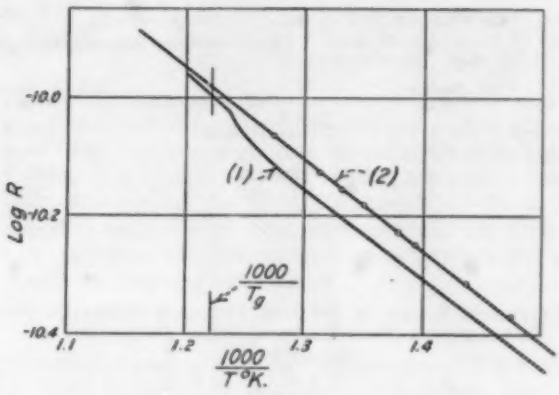

FIG. 2.—Curves (1) and (2) taken from Taylor and Rast.[1] The points on curve (2) represent data from the present investigation taken on the same sample after heating over a period of 2 months at about 440 °C.

For purposes of comparison, the rate is usually given in terms of grams per second per millimeter thickness per square centimeter of area, so that the given rate is multiplied by d/A, wherein d = thickness and A = area. Thus, substituting numerical values for helium,

$$\frac{dm}{dt} = \frac{1.064 \times 10^{-9} d}{A}\left(\frac{V_f}{T_f} + \frac{V_r}{T_r}\right)\left(\frac{dp}{dt}\right)_{760}.$$

Where dm/dt or R = rate (gm./sec./mm. thickness cm.²/-atm. pressure difference).

The volume of the sample was determined by filling with water from a calibrated burette, and the area and thickness of the sample, by direct measurement. The volume, $V_s = V_f + V_r$, of the system into which the helium diffused was determined by evacuating the system thoroughly and closing off the known volume, V, of Fig. 1. Gas was let in until pressure was built up to about 100 microns. A pressure reading with the McLeod gauge was taken; the volume, V, was opened; and another reading was taken. These operations were carried out with the entire system at room temperature; precautions were taken to see that the room temperature did not vary throughout the procedure. The volume, V_s, was calculated from the foregoing data by the simple relation of

$$p_1 V_s = p_2 (V_s + V).$$

IV. Data Obtained

The softening points and transformation points of the various glasses are given in Table II; Table III sum-

TABLE II

DATA FROM THERMAL-EXPANSION CURVES

Glass	Transformation point T_g (°C.)	$1000/T_g$ °K.	Softening point (°C.)	$1000/T$ °K.	Remarks
Pyrex-brand	545	1.222	625	1.114	
A (lead)	400	1.486	440	1.403	Quenched; first contraction at 260 °C.
B (soda)	510	1.277	545	1.222	
C (29% B_2O_3)	480	1.328	590	1.159	Quenched; first contraction at 380 °C.

TABLE III

CONSTANTS OF APPARATUS FOR DIFFERENT GLASS DIFFUSERS

Sample No.	Glass	Area of sample, A (cm.^{2})	Thickness of sample, d (mm.)	Vol. of sample, V_f (cc.)	Vol. outside furnace, V_s (cc.)
1	Pyrex-brand	94.6	1.1	41.0	458
2	" "	94.8	0.89	41.4	480
3	B (soda)	120.3	2.0	53.9	462
4	A (lead)	126.9	2.80	50.4	462
5	C (borosilicate)	126.8	2.18	54.6	462

TABLE IV

DIFFUSION RATES OF HELIUM THROUGH PYREX-BRAND GLASS AFTER TWO MONTHS' HEAT TREATMENT AT ABOUT 440°C.

R	T °C.	R	T °C.
1.725×10^{-11}	295	5.61	445
2.30	326	5.83	451
2.39	340	6.50	467
2.59	340	6.97	477
3.14	364	7.40	488
3.50	376	8.53	510
4.31	407	10.32	541
4.88	423		

* Pyrex-brand (first sample) run No. 1.

TABLE V

DIFFUSION RATES OF HELIUM THROUGH PYREX-BRAND GLASS (SECOND SAMPLE)

R	T	First run Thermal history (days)	Remarks
7.38×10^{-11}	483	1	
8.40	504	2	No previous heat treatment
		Lowered to room temp.	
8.76	515	1	
10.00	525	2	
11.2	544		
12.61	559	3	
13.7	573		
12.2	546	4	
		Second run	
1.67×10^{-11}	274	1	Sample at room temp. between runs
2.10	297		
2.58	320		
3.38	352	2	
3.88	369		
4.19	382	3	
4.58	389	4	Temp. held constant 20 hr. during 3rd and 4th day
4.87	401		
5.38	417	5	
5.62	425	6	
6.25	440	7	
6.72	452		
7.05	459		
7.40	467	8	
7.48	469		
8.00	481		
8.54	487	9	
8.86	497		
9.39	507		
	515	10	
10.62	529		
11.89	546	11	
13.29	561	12	

marizes data on the area, volume, and thickness of the samples used; and the diffusion data and a record of the thermal history are given for the various glasses in Tables IV to VIII, inclusive. The numbers in the columns on "thermal history" (Tables V through VIII) give the number of days from the start of heating the sample. The quantity, $R = dm/dt$, is expressed as grams of helium per second diffusing through a glass 1 mm. thick and 1 sq. cm. area under a pressure difference of 1 atmosphere.

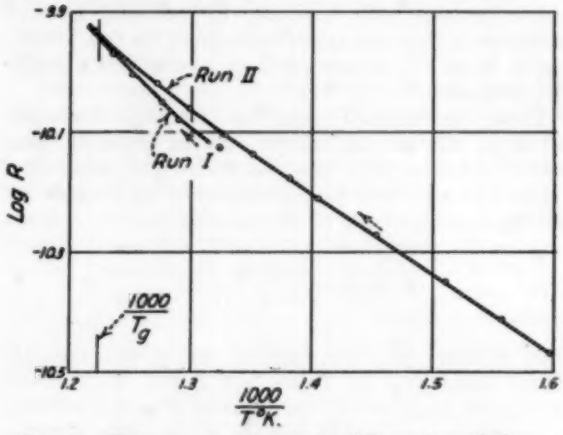

FIG. 3.—Data on second sample of Pyrex-brand glass.

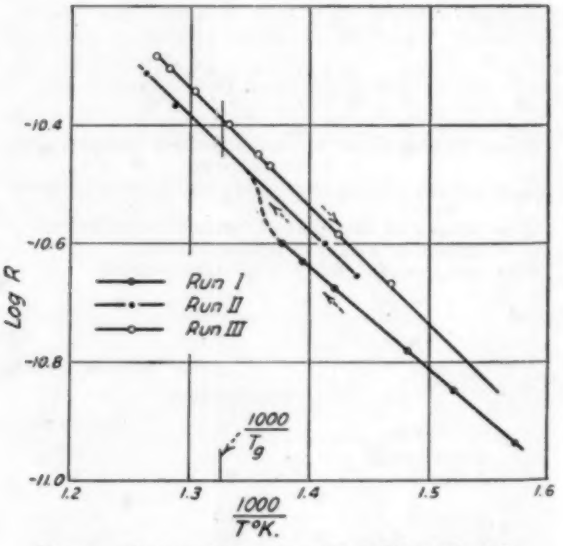

FIG. 4.—Data on test runs on borosilicate glass C.

The data in Tables IV to VIII are also shown graphically in Figs. 2 to 6, inclusive, wherein $\log_{10} R$ is plotted against $1000/T$ °K.

V. Discussion and General Remarks

Recent attempts[11] to derive a general relation between the permeability of glasses to gases and the temperature agree that the general form of the equation is

$$\frac{R = CPe^{-E_0/kT}}{d}$$

Where R = rate of diffusion.
d = wall thickness.
T = temperature in degrees Kelvin.
P = pressure.
k = Boltzman constant.
C = a proportionality constant.
E_0 = activation energy necessary to raise an atom of gas from a normal state to an activated state in which it may diffuse.

[11] See T. Alty, footnote 8, and R. M. Barrer, footnote 10.

Alty[8] has considered that this energy barrier is made up of two parts, viz., (1), which depends on the space factor and is active only at the surface of the glass, and (2), which is related to forces causing adsorption and is repeated periodically throughout the glass. Barrer[10] considers that both are repeated throughout the structure, and from this assumption he derives from Alty's results the foregoing equation.

TABLE VI

DIFFUSION RATES OF HELIUM THROUGH GLASS B (SODA)

R	T	First run: Thermal history (days)	Remarks
1.72×10^{-12}	356	1	No previous heat treatment; thermal-expansion curve showed no contraction
2.19	394	2	
2.53	422	3	
3.54	462		
3.97	472	4	
4.75	488		
6.34	510	5	

TABLE VII

DIFFUSION RATES OF HELIUM THROUGH GLASS C (BOROSILICATE)

R	T	First run: Thermal history (days)	Remarks
6.82×10^{-12}	319	1	Thermal - expansion curve showed specimen had been quenched
8.20	338		
11.10	364		
13.72	386		
15.67	401		
17.38	414	2	Temp. held at 414° for 6 hr.
20.19	430	4	
22.82	445		
24.46	454		
25.12	441	5	Temp. to 482° overnight; held at 440°C. for one day
28.13	453		
		Second run	
22.20×10^{-12}	422	1	
45.03	433		
42.80	505		
47.80	516	2	Held at 516° C. all day
		Third run	
6.80×10^{-11}	550	1	Heated to 636°C.; specimen partially collapsed
5.22	516	2	
5.05	508		
4.63	494		
3.97	476		
3.09	449	4	
2.64	432		
2.57	429		
2.16	409	5	

TABLE VIII

DIFFUSION RATES OF HELIUM THROUGH GLASS A (LEAD)

R	T	First run: Thermal history (days)	Remarks
6.52×10^{-13}	310	2	Previously heated to 350°C., then lowered to room temp.
10.4	324		
14.0	335		
17.5	344		
19.6	352		
22.7	364	3	
29.2	385		
35.8	407		
39.6	419	4	
48.0	429		
		Second run	
19.7×10^{-13}	365	1	
23.7	381	2	Held at 381°C. for 6 hr.
27.8	392		
36.8	416	3	
43.2	426		
49.3	432		
30.4	404	4	

The energy related to the space forces may arise from the repulsion and attraction existing between any two atoms when they are brought close together. It may also be governed by the size of the atomic "holes" through which the gas diffuses. Structure changes in glass will then affect the slope of the $\log R - 1/T$ curve, inasmuch as they affect these two properties, that is, the space factor and the adsorption characteristics.

Structure changes in glass may be thought of in terms of an association-dissociation process. The effects are most easily seen from a study of the volume-temperature curve of quenched and annealed glasses. When a glass is quenched, the molecular configuration, characteristic of a high temperature, is "frozen in." On reheating at the temperature at which molecular motion becomes observable, there is apparently an association process accompanied usually by a shrinkage, superimposed on the ordinary physical expansion. As a result, in this temperature range, a quenched glass may shrink with increasing temperature. Other evidence for this association-dissociation process is found from studies of absorption spectra. Variation in the chemical constitution of a glass will affect its adsorption affinity for helium. "Physical" factors, such as the density of the atomic packing in the glass, will also play a role. Thermal history as well as composition has an important bearing on the permeability of a glass to a gas diffusing through it.

Many properties of glasses have been found to depend upon heat treatment. Glasses which have been held at a constant temperature so long that the properties assume constant values are said to have been stabilized. In terms of the concept mentioned before, the association-dissociation process has reached equilibrium.

VI. Discussion of Present Data

The data of this investigation, in general, have been found to fit an equation of the following type:

$$R = APe^{-E/kT}.$$

Wherein A = a proportionality constant (other symbols have the same meaning as before).

A plot of R vs. T (°C.) is given in Fig. 7 for all the glasses studied; Fig. 8 shows plots of log R vs. $1/T$ (°K.) for the same data. In addition, the data of other investigators have been converted to the same units and plotted for comparison.

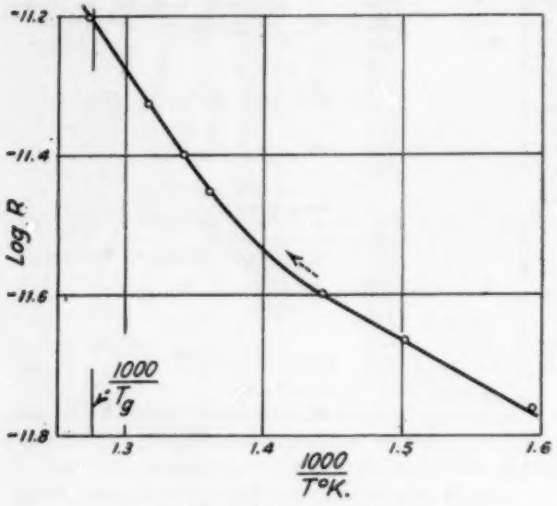

FIG. 5.—Data on soda glass B.

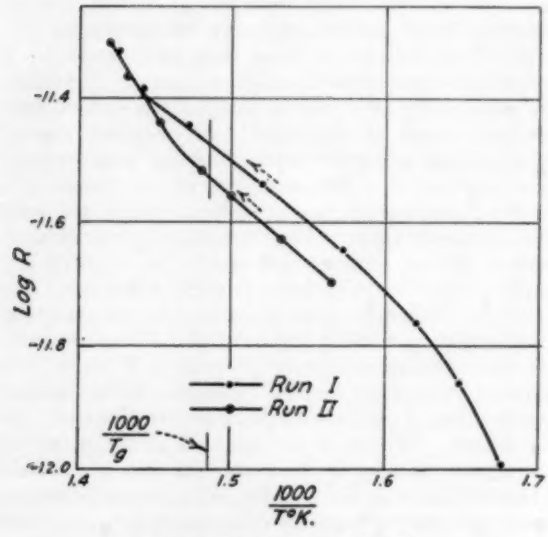

FIG. 6.—Data on lead glass A.

(1) Borosilicate and Pyrex-Brand Glasses

Inasmuch as the data on Pyrex-brand glass and glass C (both borosilicates) show certain differences as compared to the other two glasses, they will be discussed together.

The curves in Fig. 2 are taken from data of Taylor and Rast[1]; the points represent data taken on the same sample after heating over a period of two months at about 440°C.

Figure 3 shows a plot of data for a second sample of Pyrex-brand glass. For the first run on samples Nos. 1 and 2, the log R vs. $1/T$ curve shows a departure from linearity at about 20 or 25°C. below the T_g. After a short temperature interval, the curves again become linear with approximately the same slope as before, for they have undergone a displacement toward higher diffusion rates. A slight curvature at the high temperature end of the curve in Fig. 3 indicates that the sample had not yet become completely stabilized.

The activation energy for the diffusion process in the completely stabilized glass as calculated from the slope of the plot for run II, sample 1, is 7100 cal. per mol. This is computed as follows:

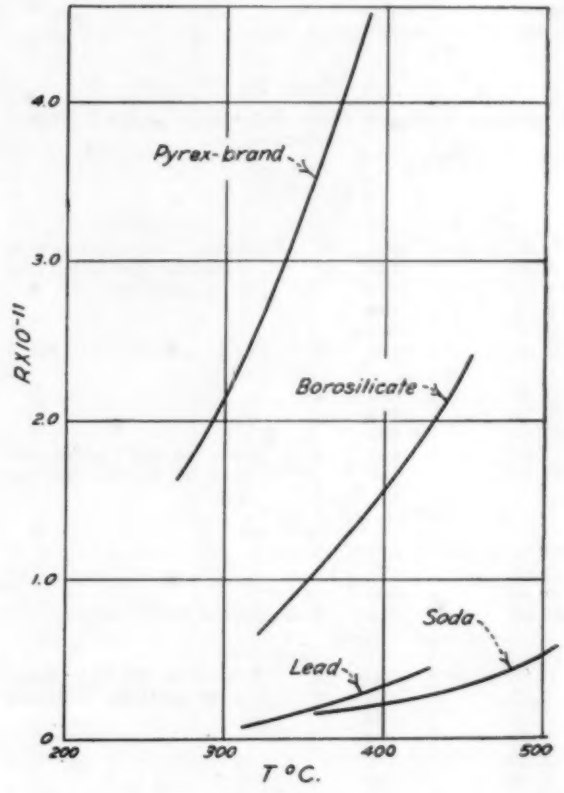

FIG. 7.—Order of decreasing permeability of glass samples.

$$E_0 = 1.99 \times 2.303 \times (\log R_1 - \log R_2)\left(\frac{1}{T_1} - \frac{1}{T_2}\right).$$

For example, in No. 1 Pyrex-brand glass,

$$E_0 = 1.99 \times 2.303 \times \frac{-9.95 + 10.30}{0.00120 - 0.001425}$$
$$= 4.58 \times \frac{0.35}{0.000225}, \text{ or } 7100 \text{ cal./mol.}$$

(2) Glass C (29% B_2O_3)

Glass C showed the same behavior as the Pyrex-brand glass in that the rate shifted to higher values with long heating, and after stabilization, the log R vs. $1/T$ curve was quite straight. The increase in diffusion rate with heat treatment unfortunately could not be followed completely in this case as the apparatus was temporarily out of order when the glass reached a temperature at which the change became observable. During the time that readings could not be taken, the furnace temperature increased about 25°; it then dropped slightly and was held for about 20 hours. By the time the next reading could be taken, the change in rate was practically complete. Presumably, if it had been possible to follow the shift, it would have proceeded according to the dotted line in Fig. 4. At the end of the second run on this glass, the furnace temperature increased to about 625°, and the sample suffered partial collapse although no leak developed. This curve (run III) therefore cannot be compared with the others as far as absolute values are concerned. The plot of log R vs. $1/T$, however, appears to be linear after this strong heat treatment. The activation energies calculated from the slopes of the plots are 8100 cal. per mol. for run II and 9200 cal. per mol. for run III.

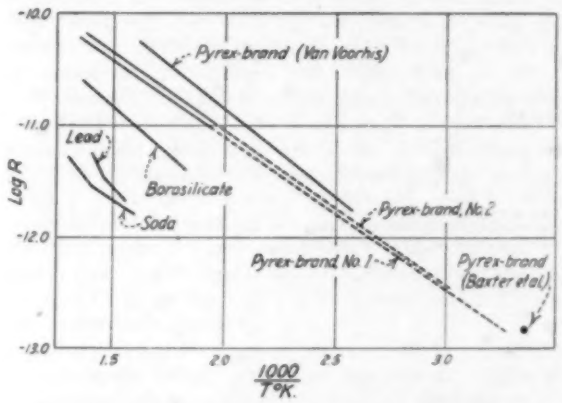

FIG. 8.—Diffusion rates for several glasses. (For Van Voorhis, see footnote 5; see also G. P. Baxter, H. W. Starkweather, and R. B. Ellestad, "Leakage of Helium Through Pyrex Glass at Room Temperature," *Science*, **68** [1769] 516 (1928).

(3) Lead and Soda Glasses

(*A*) *Glass B (Soda) Fig. 5:* Complete data could not be obtained on this glass as it devitrified partially after six days, which led to erratic results. The data obtained, however, show that from 421°C. ($1000/T$ = 1.44) to 478°C. ($1000/T$ = 1.33) the linear relation between log R and $1/T$ does not hold. Both above and below this region, the linear relation appears to hold, but there is a decided difference in slope between the two linear portions.

Because of the devitrification, no data were obtained on the stabilized glass.

An approximate value of the activation energy in the lower temperature range (near 421°C.) is E = 5100 cal. per mol.

(*B*) *Glass A (Lead) Fig. 6:* The log R vs. $1/T$ plot of the first run on this glass showed a continuously curved line until about 420° ($1000/T$ = 1.44), after which the curve suddenly increased in slope and became straight. On cooling to room temperature and reheating, the rate decreased and a linear relation was followed. A change in slope occurred at about 410° ($1000/T$°K. = 1.46), which is 10° above the value of 400° for the T_g, based on thermal-expansion data.

In this case, the shift in rate was toward lower values with the more nearly stabilized glass, and the break in the curve occurs at 410° which is above the T_g. This behavior is opposite to that of the borosilicates. Approximate values of the activation energies are E = 18,100 cal. per mol. above 410°C. and E = 9900 cal. per mol. below 410°C.

(4) Comparison of the Glasses

For the borosilicates, a shift to higher diffusion rates accompanies stabilization of the glass. After heat treatment, the log R vs. $1/T$ curve is linear, showing no discontinuity or change in slope at the "transformation point," T_g.

With the soda and the lead glasses, a region occurs in the log R vs. $1/T$ curve above which the slope becomes decidedly steeper. This break did not disappear with additional heat treatment on the lead glass. In the case of the soda glass, devitrification prevented getting data on its properties in the stabilized state.

There is apparently a shift to lower rates with approaching stabilization with the lead glass. In both the soda and lead glasses, the activation energies for helium diffusion appear to be greater at the higher than at lower temperatures.

When sudden changes in diffusion rate occur as shown by the bending of the log R vs. $1/T$ curves, it may usually be ascribed to softening of the glass because those changes generally occur near the T_g as it is measured by the expansion curve. Values of T_g are shown on the various plots.

The data obtained in the present study and summarized in Figs. 7 and 8, agree with that of Urry,[6] viz., that the order of decreasing permeability is Pyrex-brand, lead, and soda glasses; they also agree with Van Voorhis[5] in that the more basic glasses are less permeable.

The binding forces within the glass (as measured by the viscosity) do not seem to be the dominant factor in the diffusion rate of helium. For example, at the transformation point, the viscosity of a glass is usually considered to be about 10^{13} poises. Comparing the rates for the soda glass B and the 29% B_2O_3 glass at their respective transformation points, the rate for the boro-

silicate glass C is about seven times that of the soda glass, even though the transformation point for the soda glass occurs 30°C. higher than the other.

Zachariasen[12] has suggested that silica glass consists of SiO_4 tetrahedra bound by sharing corners and oriented at random, and Warren[13] has found experimental X-ray evidence for this belief. Likewise BO_3 triangles or BO_4 tetrahedra may form part of this random network. Such an arrangement leaves open spaces in the glass, and it has been suggested that some of these holes may be occupied by cations such as Na^+, Ca^{++}, Pb^{++}, etc. It would seem reasonable then that these open spaces may connect to form irregular channels of atomic dimensions through which gas may diffuse. Such a picture would account for the fact that the more basic glasses, which contain a higher percentage of cations, show a lower permeability than fused silica or glasses high in silica, such as Pyrex-brand glass or glass C of this investigation.

It may be of interest here to note the relative rates of diffusion of various gases through fused silica and Pyrex-brand glass and the atomic radii of the diffusing gases. The larger atoms or molecules diffuse more slowly. "Chemical" factors, however, undoubtedly play an important role.

RELATIVE RATE OF DIFFUSION THROUGH FUSED SILICA AT 500°

Gas	Radius (Å)	Relative rate
Ne	1.60	1.0
H_2	1.48	3.2
He	0.53	70.0

Argon, $r = 1.91$ Å, diffuses very slowly, even at 950°. Data for the relative rates of H_2 and He are taken from the paper of Williams and Ferguson[3] and those for He and Ne from T'Sai and Hogness[4]; the atomic radii are from Lange.[14]

[12] W. H. Zachariasen, "Atomic Arrangement in Glass," *Jour. Amer. Chem. Soc.*, **54** [10] 3841–51 (1932); *Ceram. Abs.*, **12** [4] 145 (1933).

[13] B. E. Warren, "X-Ray Determination of Structure of Glass," *Jour. Amer. Ceram. Soc.*, **17** [8] 249–54 (1934).

[14] N. A. Lange, Handbook of Chemistry, 1st ed., p. 48. Handbook Publishers, Inc., Sandusky, Ohio, 1934; *Ceram. Abs.*, **14** [10] 262 (1935).

The data on Pyrex-brand glass obtained in this laboratory by Rast and Taylor[1] show that helium diffuses at 512°C. about forty-five times faster than hydrogen.

The inverse relation between the size of gas atoms or molecules and the diffusion rate is purely qualitative. There is abundant evidence that such factors as the electrical polarizability of the gas and, as shown in this investigation, variations in the degree of stabilization of the glass with respect to association or dissociation processes have an important influence on diffusion rates.

VII. General Summary

An investigation of the rate of diffusion of helium at temperatures from 300° to 500°C. through four glasses of widely different composition showed that in each case the heat treatment of the glass had a marked effect on the permeability to helium. For a limited temperature range, a plot of log R vs. $1/T$ was linear, but in general this was not true for the entire temperature range. With two of the glasses, both borosilicates, heat treatment caused an increase in the diffusion rate; with a high lead glass, heat treatment caused a decrease. The data on the soda glass are incomplete, owing to devitrification. The plots of log R vs. $1/T$ show a pronounced change in slope near the transformation point for the lead and soda glasses. With Pyrex-brand glass, the change is much less marked, and with another borosilicate glass no change in slope could be detected. The changes in diffusion rate may be attributed to internal adjustments in the glasses as they become sufficiently soft to permit molecular rearrangement and consequent approach to a stabilized state.

Helium appears to work its way through small holes of atomic size in the network of atoms which constitute the glass structure. As the glass becomes more basic so that positive ions, such as lead or sodium, can occupy some of these holes, the freedom of movement of helium is impeded and its rate of diffusion becomes less. Glasses high in silica and/or boric oxide show the greatest permeability. A silicate glass of high alkali content (and no B_2O_3) shows the lowest permeability.

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RESISTANCE OF GLASS BOTTLES TO NEUTRAL ALCOHOLIC SOLUTIONS*

By Frank R. Bacon and O. G. Burch

Abstract

Bottle surface tests with alcoholic solutions of various strengths and with distilled water show that corrosion decreases with increasing alcoholic concentration. The tendency to form flakes usually, though not always, decreases with increasing alcoholic concentration. The results show no relation that will hold for all glass bottle compositions between extraction values with distilled water in any accelerated test and extraction values or the tendency to form flakes in neutral alcoholic solutions.

I. Introduction

The authors stated in a previous paper[1] that at least 90% of the products sold in glass containers are acidic in nature. Gin was referred to as one of the products of a neutral or alkaline nature which are usually packaged in glass. Commercial bottled gin is essentially neutral with a pH, depending on the manufacture, which varies approximately between 6.0 and 6.5. As the solution is unbuffered, it is obvious that if the glass bottle should yield even a relatively small amount of alkali to the product, gin would become alkaline, and that this condition actually occurs commercially may be readily proved. The measurement of the pH of any of the so-called dry gins as they reach the consumer reveals the fact that at least 75% of them are alkaline. Certain bottles have been found with a pH value as high as 8.4.

The general trend of distillers since the repeal of prohibition has been to make gins less acidic and therefore more nearly neutral at the time of bottling. The packaging of this nearly neutral gin in available glass bottles has often resulted in the formation of flakes or glass spicules caused by the action of the gin on the glass.

To protect themselves against this flake formation in gin, several distillers have adopted standard test procedures to measure the suitability of various glass compositions as containers for liquor, and they have set up specifications, based on these test procedures, that liquor containers purchased by them must meet.

These tests, which are in common use, have aroused considerable comment in the glass industry during the past two years. They are carried on in autoclaves under accelerated conditions with distilled water as a leaching medium, the time currently used varying from one to five hours at 121°C.

The present studies are concerned with the problem of forecasting, by an accelerated test, the resistance of glass containers to a relatively neutral alcoholic solution, such as gin. The bottle manufacturers have been prone to accept as valid the contention of distillers that accelerated distilled-water tests, such as a 1- to 5-hour autoclave test at 121°C., will rank bottles in the same order of resistance as will obtain with gin at room temperature. Commercial dry gins manufactured in this country contain from 40 to 47% by volume of ethyl alcohol. The present studies were undertaken to determine what effect, if any, increasing alcoholic concentration has on the corrosion of typical glass bottles.

Turner[2] reported experiments with four types of English 4-ounce bottles carried out at 30° and 60°C. with solutions of 0, 10, 20, 40, and 60% alcohol by volume. His results are at variance with commercial experience in the packaging of gin in bottles available in the United States. He reported the formation of flakes in all four types of bottles, when filled with 40% alcoholic solution, within six hours, at temperatures of 30° and 60°C. On duplicate bottles, filled with distilled water, he found that from two to five days were required for formation of flakes at 60°C. and five to eleven days at 30°C. Inasmuch as 30°C. is not an abnormal room temperature in this country, it is evident that if representative glass bottle compositions made here were no more resistant to alcoholic solutions than those with which Turner worked, every bottle of gin would develop flakes before it left the distillery. That such a condition is not true is known from the results of tests in which gin was stored in commercial glass bottles for a number of years. These tests, carried on at room temperature with gin in new half-pint flasks, using practically every glass bottle composition manufactured in the United States, have not shown the development of flakes in a single bottle in a period of fourteen months.

Turner, furthermore, reported the formation of flakes in all four compositions with which he worked, using distilled water as the leaching medium, in times varying between five and eleven days at a temperature of 30°C. In some current work being carried on by the authors with eleven compositions of 4-ounce bottles, representing a good cross section of bottle glass compositions manufactured in this country, no flakes have developed in bottles containing distilled water after six months' storage at room temperature (25° to 32°C.).

II. Experimental Results

In 1936, one of the authors, attempting to corroborate Turner's work, used 6-ounce round bottles in a series of experiments with various concentrations of

* Presented at the Autumn Meeting, Glass Division, American Ceramic Society, Skytop, Pa., September 9, 1939. Received September 15, 1939.

[1] F. R. Bacon and O. G. Burch, "Effect of Time and Temperature on Accelerated Chemical Durability Tests Made on Commercial Glass Bottles," *Jour. Amer. Ceram. Soc.*, **23** [1] 1–9 (1940).

[2] W. E. S. Turner, "Testing of Glass Containers for Chemical Durability," *Jour. Amer. Ceram. Soc.*, **18** [5] 135–41 (1935).

alcohol and under various temperature conditions. The glass composition was SiO_2 73.5, R_2O_3 1.0, CaO 6.0, MgO 4.0, BaO 0.4, and Na_2O 15.1%.

The bottles were rinsed well with tap water and then with distilled water, partially filled with 160 cc. of the desired solution, tightly capped, and exposed to the desired conditions. When possible, they were examined periodically for flake formation. At the end of the test period, they were removed from the water bath or autoclave used to produce the desired temperature condition and allowed to cool; their contents were transferred to Pyrex-brand beakers, and the solutions were filtered through extremely fine filter paper. The insoluble material was washed well with portions of solutions corresponding to those used in the test and was ignited in weighed platinum crucibles; a few drops of sulfuric acid were added to the material to insure the conversion of basic materials to sulfates. A definite amount of sulfuric acid was added to the respective filtrates, which were then evaporated to dryness in weighed platinum dishes and ignited to determine the amount of extracted soluble material as sulfates. The tests were conducted at 60°, 90°, and 126°C. Table I shows the results obtained.

TABLE I

TESTS WITH IDENTICAL 6-OUNCE BOTTLES

Alcohol (% by vol.)	Temp. (°C.)	Total time (hr.)	Soluble solids as sulfates (mg./l.)	Insoluble solids (mg./l.)	1st appearance of flakes (hr.)	Degree of flaking*
0	60	144	54	0		0
10	60	144	41	0		0
20	60	144	30	Trace	144	+
40	60	144	23	0		0
0	90	24	180	12	4	+
10	90	24	160	17	4	+
20	90	24	150	22	4	+
40	90	24	89	9	16	+
50	90	24	55	7	20	+
0	126	1½	170	18		3
10	126	1½	160	16		2
20	126	1½	140	14		1
30	126	1½	59	0		0
40	126	1½	39	0		0
50	126	1½	31	0		0
0	126	3	270	31		5
10	126	3	240	23		4
20	126	3	180	16		3
30	126	3	110	4		2
40	126	3	76	3		1
50	126	3	61	0		0

* Presence of flakes is indicated by +, absence by 0, and progressive amounts by progressive numbers.

The bottles used for the experimental work reported in Table II were 4-ounce Boston round bottles of ten of the eleven compositions referred to in the previous paper.[1] (Bottle G was not included in this work because the supply was exhausted.) The range of compositions used covers that representative of commercial container glasses being made in this country at the present time. Their alkali contents vary from 14.5 to 16.5%, alumina from 0.5 to 3.0%, and dibasic oxides from 8.0 to 11.5%. Both calcite and dolomite lime glasses were included.

TABLE II

TESTS WITH 4-OUNCE BOSTON ROUND BOTTLES

		14 days at 75°C.	
Bottle No.	Alcohol (% by vol.)	Total solids as sulfates (mg./l.)	1st appearance of flakes (days)
A	0	130, 130	
	20	81, 80	
	40	59, 47	
	60	39, 34	
B	0	250, 250	
	20	37, 43	
	40	23, 23	
	60	20, 20	
C	0	190, 190	2, 2
	20	115, 120	3, 3
	40	74	3
	60	50, 46	4, 6
D	0	150, 150	4, 4
	20	81, 110	6, 6
	40	68	6
	60	30, 31	
E	0	100, 100	
	20	58, 61	
	40	41, 39	
	60	30, 30	
F	0	190, 190	4, 4
	20	94, 110	4, 4
	40	70, 71	5, 9
	60	40, 57	
H	0	330, 330	1, 1
	20	200, 190	1, 1
	40	97, 95	1, 1
	60	48, 56	4, 5
I	0	230, 240	1, 1
	20	155, 155	1, 1
	40	93, 93	1, 1
	60	61, 76	3, 3
J	0	280, 290	1, 1
	20	175, 175	1, 1
	40	91, 96	1, 1
	60	53, 49	1, 1
K	0	670, 680	1, 1
	20	300, 310	3, 3
	40	115, 150	3, 4
	60	33, 33	

The bottles used for the data given in Table II were rinsed twice with tap water and twice with hot distilled water. Bottles subjected to water tests were filled with 118 cc. of distilled water, previously boiled; those subjected to corrosion by the various alcoholic solutions were filled with 115 cc. of solution. The lesser volume was used with alcoholic solutions because of the greater thermal expansion of such solutions. The bottles were closed with threaded caps, containing black alkali-resistant liners, and were immersed to a depth equivalent to that of the solution within the bottle in a water bath maintained at exactly 75°C. for fourteen days. Each bottle was examined daily for the presence of flakes, and the time at which flakes were detected in each bottle was noted. At the end of the test period, the

bottles were removed from the bath and cooled to room temperature, the contents of each were then transferred to a Pyrex-brand beaker, each bottle was well washed, and the wash water was added to the beakers. A small amount of sulfuric acid was added to each solution, and the solutions were evaporated down to small volumes, transferred to previously ignited and weighed platinum dishes, evaporated to dryness, and ignited to constant weight. The total amount of material extracted from the glass was therefore determined as sulfates. The values in Table II have been converted to milligrams per liter.

TABLE III

AUTOCLAVE TESTS WITH WATER IN 4-OUNCE BOTTLES* ALKALI EXTRACTED (MG. NaOH/LITER)†

Bottle	At 121°C. 1 hr.	At 121°C. 5 hr.
A	18	41
	18	41
B	6	27F
	7	30F
C	14F	37F
	13F	39F
D	10	28F
	10	27F
E	13	29
	13	28
F	23F	55F
	22F	56F
H	19F	64F
	18F	65F
I	26F	54F
	26F	54F
J	18F	62F
	19F	61F
K	22F	96F
	23F	98F

* Data taken for comparison from previous paper.[1]
† Symbol F indicates presence of flakes at conclusion of test.

The results given in Table IV were obtained on a set of half-pint liquor flasks of eight commercial compositions numbered 1, 2, 3, 4, 5, 6, 8, and 9.

The results in column (2) of Table IV were obtained by rinsing one of each lot of bottles with tap water and then with hot distilled water. Each bottle was partially filled with 160 cc. of previously boiled distilled water, tightly capped with screw caps containing black alkali-resistant liners, and placed in an autoclave. The temperature of the autoclave was brought up to 121°C. in 30 minutes; this temperature was maintained for 60 minutes, and the autoclave pressure was then reduced to atmospheric during an additional 30-minute period. The bottles were removed; 100 cc. of solution was pipetted from each and titrated to a methyl red end point with $N/50$ H_2SO_4. The results are expressed as milligrams of NaOH per liter. This test is in current use by one distiller to evaluate the resistance of glass bottles for packaging liquor.

Columns (3), (4), and (5) of Table IV show, respectively, the days elapsed until flakes appeared, the insoluble matter (amount of flakes in milligrams per liter of solution) present at the end of 30 days, and the soluble material as sulfates (in milligrams per liter) extracted from the glass surface in the 30-day period when other lots of bottles, Nos. 1 to 9, inclusive, were filled with 90-proof gin and maintained at 70°C. for 30 days. The insoluble material was determined by filtering each solution and igniting the residue in weighed platinum crucibles. The soluble material was determined by adding a small amount of sulfuric acid to each filtrate and evaporating to dryness, followed by ignition to constant weight in previously ignited and weighed platinum dishes.

Columns (6) and (7) of Table IV show, respectively, the amount of alkali extracted from the surface of each bottle (determined by titration to the methyl red end point in milligrams of NaOH per liter) and the total amount of material as sulfates extracted from each bottle (in milligrams per liter), when samples of bottles Nos. 1 to 9 were filled with 90-proof gin and stored for fourteen months at room temperature, which varied between 25° and 32°C.

III. Discussion of Results

(1) Tests on 6-Ounce Bottles

(*A*) *Temperatures Below Boiling Point of Alcohol:* The results in Table I show that at 60°C., the only bottle to develop flakes at the end of 144 hours was that

TABLE IV

TESTS WITH 8-OUNCE LIQUOR FLASKS

Bottle No.	Distilled water, 160-cc. fill, 1 hr. at 121°C. (mg. NaOH/l.)	Gin, 30 days at 70°C. 1st appearance of flakes (days)	Gin, 30 days at 70°C. Insoluble solids (mg./l.)	Gin, 30 days at 70°C. Net soluble solids as sulfates (mg./l.)	Gin, 14 months at room temp. (Mg. NaOH/l.)	Gin, 14 months at room temp. Net total solids as sulfates (mg./l.)
(1)	(2)	(3)	(4)	(5)	(6)	(7)
1	30		0	100	12	31
2	21		0	80	9	21
3	18	2	7	110	8	20
4	8	29	4	38	2	11
5	22	2	18	140	7	22
6	20	3	11	130	7	20
8	41	3	35	200	6	22
9	29	8	18	180	6	26

containing 20% alcohol. The amount of flakes in this bottle was too minute for quantitative determination. The total corrosion of the glass by the various solutions used, as shown by the total amount of material as sulfates extracted from each bottle, decreased as the alcoholic concentration of the solution increased. A comparison of these results with those obtained by Turner[2] shows that at 60°C. he obtained flake formation in 40% alcoholic solution within six hours for all types of bottles tested, whereas the particular composition used in the current test showed no flakes at the same concentration of alcoholic solution in 144 hours.

(*B*) *Temperatures Above Boiling Point of Alcohol and Below Boiling Point of Water:* In tests conducted for 24 hours at 90°C., with alcoholic concentrations of 0, 10, 20, 40, and 50% by volume, the time of the first appearance of flakes could not be distinguished between 0, 10, and 20% alcoholic solutions. These three solutions developed flakes at the end of four hours; 40% alcohol showed flakes at 16 hours and 50% at 20 hours. The total amount of flakes, determined gravimetrically at the end of a 24-hour period, shows that they increased as the alcoholic concentration was increased up to 20% by volume and then decreased as the alcoholic concentration was increased to 50% by volume. These results seem to be consistent with the results of the test conducted at 60°C., wherein the 20% alcohol solution was the only one to produce flakes. The total corrosion of the bottles, however, as determined by the total amount of material extracted from each bottle, decreased slightly as the alcoholic content of the solution was increased from 0 to 20% by volume, and it decreased rapidly as the percentage of alcohol was increased from 20 to 40%.

(*C*) *Temperatures Above Boiling Point of Water:* Table I shows that 1½- and 3-hour tests were conducted with solutions of alcoholic concentrations of 0, 10, 20, 30, 40, and 50% at 126°C. Because it was necessary to conduct such tests in an autoclave, it was impossible to examine the bottles during the test to determine the exact time at which flakes occurred. In both the 1½- and 3-hour tests at this temperature, the 0% alcoholic solution showed the most flakes as determined both by observation and gravimetrically. Both the total amount of flakes and that of soluble matter extracted from the bottles decreased as the alcoholic concentration was increased from 0 to 50%. As in the test at 90°C., the 1½-hour test at 126°C. shows a rapid rate of decrease in total amount of corrosion at an alcohol concentration between 20 and 40%.

Another interesting fact is that, whereas in 24 hours at 90°C. a 50% alcoholic solution showed a weighable quantity of flakes (7.5 mg. per liter) when the total amount of extracted material as sulfates was 57 mg. per liter, in the 3-hour test with this same solution at 126°C., no flakes were obtained, although the total amount of extracted material as sulfates was 61 mg. per liter.

(2) Tests Conducted on 4-Ounce Bottles

Table II gives the results of tests on 4-ounce bottles of ten different compositions with alcoholic solutions of 0, 20, 40, and 60% by volume at 75°C., which lead to some interesting observations. A portion of Table IV from a previous paper,[1] showing the results of autoclave tests with these bottles, is reproduced in Table III to emphasize certain comparisons.

Tables II and III show (1) that for each of the ten compositions used, the resistance of the bottle to the various solutions increases as the alcoholic concentration of the solution increases and (2) that the rate of decrease in attack or corrosion of the bottle as the alcoholic concentration of the solution increases differs for each composition tested.

Example (*a*): As the alcoholic concentration of the solution is increased from 0 to 20%, the total corrosion on the glass surface for bottles A, C, E, H, I, and J decreases by about 40%. When the same increase in alcoholic concentration is made in bottle B, the decrease in total attack is about 85%, and under the test conditions, bottle B, which ranks sixth in resistance to 0% alcohol, is first in resistance to 20% alcohol.

Example (*b*): Bottle K, inferior in resistance to all other bottles for 0, 20, and 40% alcoholic solutions, is superior to bottles A, C, F, H, I, and J in resistance to 60% alcohol.

(3) The total material extracted does not always classify the bottle correctly as to resistance to flaking when it is in contact with the various solutions. With respect to the total amount of material extracted, bottle K is inferior to bottles H, I, and J at alcoholic concentrations of 0, 20, and 40%, but bottles H, I, and J develop flakes in 20, 40, and 60% alcoholic solutions before bottle K under the same conditions. Bottle D furthermore is superior to bottle A in total corrosion resistance to 20, 40, and 60% alcoholic solutions, but it is inferior to bottle A in resistance to flake formation.

(4) Many obstacles are encountered in any attempt to predict the resistance of glass bottles to total material extracted or formation of flakes with a 40% alcoholic solution from the titration values obtained in a one-hour autoclave test with distilled water (the commercial test used by at least one distiller).

Example (*a*): In a one-hour autoclave test, bottles A, H, and J show the same amount of resistance. With 40% alcohol at 75°, bottle A shows less total material extracted in two weeks than bottles H and J. Under the test conditions with 40% alcohol, bottle A also shows no flakes in fourteen days, whereas flakes occur in bottles H and J in one day.

Example (*b*): In the autoclave test, bottle K is definitely inferior to bottles H and J; with 40% alcohol at 75°, however, bottle K requires three to four days to form flakes, whereas flakes form in bottles H and J within one day.

Example (*c*): In the autoclave test, bottle A yields considerably more titratable alkali than bottle C, but in the test with 40% alcohol, bottle A is superior to bottle C in resistance to flaking.

(5) Some of those concerned in the packaging of gin in glass believe that a one-hour autoclave test with distilled water at 121°C. is not sufficiently severe to predict the suitability of bottles for storing gin over long periods of time. Autoclave tests with distilled water,

therefore, have been used for substantially longer periods, e.g., for approximately five hours at 121°C. If the results obtained in a five-hour autoclave test with distilled water at 121°C. are correlated with the resistance of glass bottles to 40% alcoholic solutions, the discrepancies are even more pronounced than those resulting from attempts to interpret one-hour autoclave tests in such terms.

Tables II and III, for example, show that in a five-hour autoclave test at 121°C., bottle A yields a higher extraction value than bottles C and D; but in the test with 40% alcohol, bottle A is superior to bottles C and D in resistance to flaking and total corrosion. Bottles F and I likewise show about equal resistance in the five-hour autoclave test, but bottle F is superior to bottle I in the 40% alcohol test in resistance to flaking and total corrosion. In a five-hour autoclave test with distilled water, bottle K is considerably inferior in resistance to bottles H, I, and J, but it has considerably greater flake resistance to 40% alcohol than any of these three bottles.

At the end of the 14-day period, all of the alcoholic solutions in the 4-ounce bottles were slightly opalescent, regardless of whether or not flakes had appeared. As the alcoholic concentration of the solution was increased, the degree of opalescence was also increased. This was true for every composition. The exact explanation of the greater tendency of alcoholic solutions to become opalescent is not known, but it is surmised that it is related to the effect of alcoholic concentration on the solubilities of alkali silicates.

There are some discrepancies in this work in the time noted for first appearance of flakes for certain bottles compared with that reported earlier for similar bottles.[1] In the previous work, for example, bottle F showed no flakes in seven days at 75°C., whereas flakes were detected in four days at that temperature in the present studies. This difference is probably due to the fact that bottles were examined more critically and more frequently in the present work.

(3) Tests on 8-Ounce Flasks

As stated before, some glass manufacturers have accepted as valid the contention that the amount of alkali extracted from a bottle surface by distilled water in an accelerated autoclave test will predict the relative resistance of a bottle to flake formation when gin is packaged therein. The tests on 4-ounce bottles show that this is not true for a number of glass compositions with 20, 40, and 60% alcoholic solutions.

Table IV shows that there is no consistent relation between the autoclave tests conducted with distilled water and the resistance of glass to the action of gin, which will hold for all glass compositions. In the one-hour autoclave test with a partial fill of distilled water at 121°C., bottle 4 is by far the most resistant of the lot (see Table IV). Judged by this test, bottles 2, 3, 5, and 6 appear to be grouped together in resistance; bottles 1 and 9 are slightly inferior in resistance; and bottle 8 is by far the least resistant. If the results obtained in 30 days at 70°C. are observed when other samples of these lots of bottles are filled with gin, bottles 1 and 2 have the greatest flake resistance, for neither showed flakes during the entire course of the test. Bottle 4 ranks next in resistance to flake formation, but flakes developed during the test, despite the fact that the total amount of corrosion of the glass surface was less than that on bottles 1 or 2. Bottles 3 and 5, which were definitely superior in the autoclave test to bottles 8 and 9, developed flakes with gin one day before bottle 8 and six days before bottle 9, despite the fact that the total amount of corrosion of the glass surface on bottles 8 and 9 at the end of 30 days was greater than that on bottles 3 and 5. The performance of bottles 1 and 9 in the gin test (particularly their resistance to flake formation) compared with the performance of bottles 3, 5, and 6 illustrates the fact that autoclave tests with distilled water do not always forecast the resistance of a bottle to flaking when it is exposed to the action of gin.

The results of the room-temperature tests (Table IV) show (*a*) that bottle 4 has the greatest resistance to total corrosion in a 14-month period; bottles 8 and 9, however, which were inferior in the autoclave test, compare favorably with bottles 2, 3, 5, and 6, the average in that test; and (*b*) that 14 months' storage at room temperature, which seems to be a reasonable expectancy of the length of time gin might be stored in a bottle at room temperature in the trade, does not cause formation of flakes in any of the bottles tested.

The equivalent of 30 days at 70°C. in time of storage of gin at room temperature is not known. The results on various lots of bottles with distilled water indicate that one day at 75°C. is equivalent to approximately six months' storage at room temperature. Storage for 30 days at 70°C. should be equivalent in severity to somewhere between ten and fifty years at room temperature. Bottles 3 and 5, showing flakes in two days at 70°C., showed no flakes in fourteen months at room temperature. The conclusion is certain, therefore, that two days' storage with gin at 70°C. is more severe in action than fourteen months at room temperature.

IV. Conclusions

From the experimental data presented, the following conclusions may be drawn concerning the glass compositions used in this study:

(1) The resistance of glass to corrosion by alcoholic solutions increases as the alcoholic content of the solution increases.

(2) The resistance of glass to flaking when it is in contact with alcoholic solutions increases in general as the alcoholic concentration is increased. This, however, is not true of all glass compositions.

(3) The total amount of material extracted from a glass surface by an alcoholic solution is no index of the likelihood of flakes developing therein.

(4) There is no constant relation between resistance of bottle glasses to the action of distilled water at any given temperature between 75° and 121°C. and the resistance of the same glasses to the action of alcoholic solutions at temperatures between room temperature and 75°C., which holds for all glass compositions.

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STABILITY OF A KILN STACK*

By T. W. Garve

Abstract

Mathematical proof is presented that the wind pressure on a round stack is two-thirds that of a square stack with the wind square to one side. A reconsideration is given of a stack section[1] where tension occurred, and a correction is presented. A convenient method and its application is also given for calculating the stability of a kiln stack upon the soil. The application of the "kern" theorem is discussed, using the kern for the *worst* condition, viz., with wind blowing *diagonally* against a square stack.

I. Mathematical Proof for Wind Pressure on Round Stack

In another paper,[1] the writer stated that the wind pressure against a round stack is but two-thirds or about 67% that of a square stack, but no proof was given. Inasmuch as this statement is often found in engineering handbooks without substantiation, it seems in place to submit a proof. Such relationship, however, exists only for the wind acting at right angles to one side.

In Fig. 1, the wind pressure is acting against a surface square to the direction of the wind. For case A, the pressure per square foot area is $w/1$ or w.

In Fig. 1 (*B* and *C*), however, the wind pressure is acting against a surface with an inclination to the direction of the wind. The exposed area in case B is making an angle, α, with the wind direction. Because

$$\text{Sin } \alpha = \frac{\text{vertical area}}{\text{inclined area}},$$

$$\text{Inclined area} = \frac{\text{vertical area}}{\sin \alpha} = \frac{1 \text{ sq. ft.}}{\sin \alpha}.$$

In other words, a larger area is now exposed to the same amount of wind than at A. Thus for case B

$$\text{Pressure/sq. ft. area} = \frac{w}{\frac{1 \text{ sq. ft.}}{\sin \alpha}} = w \sin \alpha.$$

This force is in the direction of the wind.

The wind pressure per square foot of the inclined area is less than that of the vertical area because the same amount of wind pressure is distributed over a larger area.

Any surface can take only that part of wind pressure which is at right angles to it; the component acting at right angle to the surface is the sinus of the wind pressure, so that sin α must be used again as follows:

$$w \sin \alpha \cdot \sin \alpha = w \sin^2 \alpha = \text{pressure/sq. ft. at right angles to surface.}$$

In the circular stack section in Fig. 2, wind pressure w is resolved into one component parallel to the tangent and another component at right angles to the tangent; the pressure at right angles for any chosen point, therefore, is $w \sin^2 \alpha$ whose tangent (equivalent to the inclined area) is forming angle α with the direction of the wind. Angle α appears again in the triangles or in the parallelograms of forces. The component parallel to the direction of the wind must be

$$w \sin^2 \alpha \cdot \sin \alpha = w \sin^3 \alpha.$$

The components in the direction of B therefore balance each other.

The wind is affecting the curved exposed area in varying degrees; the force $w \sin^3 \alpha$, acting on the exposed half of the stack cylinder, will vary between the limits $\frac{\pi}{2}$ and zero; thus the integral of all elements will be

$$\text{Affected area} = 2wrh \int_0^{\frac{\pi}{2}} \sin^2 \alpha \, d\alpha, \qquad (1)$$

$$= \frac{2}{3} w 2rh.$$

The projection of the cylinder is $2rh$. The effective area equals two-thirds of the projection of the cylinder. This equation of course applies to any height of stack.

$$I = \int_0^{\frac{\pi}{2}} \sin^3 \alpha \, d\alpha \text{ (to be solved)}$$

$$I = \int \sin^3 \alpha \, d\alpha$$

$$= \int \sin \alpha \times \sin^2 \alpha \, d\alpha.$$

Since $\cos 2\alpha = 1 - 2 \sin^2 \alpha$

$$\text{Sin}^2 \alpha = \frac{1}{2} - \frac{1}{2} \cos 2\alpha$$

$$d\alpha = \frac{1}{2} d2\alpha.$$

$$I = \int \sin \alpha \times \left[\frac{1}{2} - \frac{1}{2} \cos 2\alpha\right] \times \frac{1}{2} \times d2\alpha$$

$$= \int \sin \alpha \left[\frac{d\alpha}{2} - \frac{1}{4} d \sin 2\alpha\right],$$

because $\int \frac{1}{2} \cos 2\alpha \times \frac{1}{2} d2\alpha = -\frac{1}{4} \times \sin 2\alpha.$

If the right-hand term is divided into two parts, then

$$I = \int \frac{\sin \alpha}{2} d\alpha - \frac{1}{4} \int \sin \alpha \, d \sin 2\alpha$$

$$= -\frac{1}{2} \cos \alpha - \frac{1}{4} \int \sin \alpha \, d \sin 2\alpha. \qquad (2)$$

Now since $\int u \, dv = uv - \int v \, du,$

Then $\int \sin \alpha \, d \sin 2\alpha = \sin \alpha \sin 2\alpha - \int \sin 2\alpha \, d \sin \alpha$

$$= \sin \alpha \sin 2\alpha - \int 2 \sin \alpha \cos \alpha \times \cos \alpha \, d\alpha.$$

* Received September 5, 1939.

[1] T. W. Garve, "Stability and Design of a Kiln Stack," *Jour. Amer. Ceram. Soc.*, **5** [7] 455–67 (1922).

Because $\sin 2\alpha = 2 \sin \alpha \times \cos \alpha$,
and $d \sin \alpha = \cos \alpha \, d\alpha$.

$$\text{Therefore } \int \sin \alpha \, d \sin 2\alpha = \sin \alpha \sin 2\alpha - 2 \int \sin \alpha \cos^2 \alpha \, d\alpha$$

$$= \sin \alpha \sin 2\alpha - 2 \int \sin \alpha (1 - \sin^2 \alpha) \, d\alpha$$

$$= \sin \alpha \sin 2\alpha - 2 \int \sin \alpha \, d\alpha - \sin^3 \alpha \, d\alpha$$

$$= \sin \alpha \sin 2\alpha + 2 \cos \alpha + 2 \int \sin^3 d\alpha.$$

Introducing this result in equation (2),

$$I = -\frac{1}{2} \cos \alpha - \frac{1}{4} \sin \alpha \sin 2\alpha - \frac{1}{2} \cos \alpha - \frac{1}{2} \int \sin^3 \alpha \, d\alpha.$$

From the starting equation,

$$I = \int \sin^3 \alpha \, d\alpha = -\cos \alpha - \frac{1}{4} \sin \alpha \sin 2\alpha - \frac{1}{2} \int \sin^3 \alpha \, d\alpha.$$

$$\text{Therefore } \frac{3}{2} \int \sin^3 \alpha \, d\alpha = -\cos \alpha - \frac{1}{4} \sin \alpha \sin 2\alpha.$$

$$\text{And finally, } \int \sin^3 \alpha \, d\alpha = -\frac{2}{3} \cos \alpha - \frac{1}{6} \sin \alpha \sin 2\alpha$$

$$= -\frac{2}{3} \cos \alpha - \frac{1}{3} \sin^2 \alpha \cos \alpha + \text{constant}.$$

Therefore, the definite integral,

$$\int_0^{\frac{\pi}{2}} \sin^3 \alpha \, d\alpha = \left[-\frac{2}{3} \cos \alpha - \frac{1}{3} \sin^2 \alpha \cos \alpha \right]_0^{\frac{\pi}{2}}$$

$$= \left\{ \begin{matrix} 0 \\ -\left(-\frac{2}{3}\right) \end{matrix} \right\} = +\frac{2}{3}.$$

II. Tension in Stack Section

In the earlier paper,[1] the sections of a square kiln stack were figured like beams for compression and tension, and a negative value or tension was obtained for the last section 3–3 (see Fig. 3-A). An attempt was made to correct this by changing the 12-inch wall to a 16-inch wall. The fiber stress per square foot or square inch was given as

$$f = \frac{P}{A} \pm \frac{M}{S}. \qquad (3)$$

Where P = weight of stack section.
A = area of cross section.
M = bending moment.
S = section modulus of section.

If an inside stack clearance of 4 sq. ft. is maintained and the outside is 6 feet 9 inches square (nominal, 6 feet 8 inches; actual, 6 feet 9 inches), the following correction is introduced:

A = area of section $= 6.75^2 - 4^2 = 29.56$ sq. ft.

S = section modulus for section $= \frac{6.75^4 - 4^4}{6 \times 6.75} = 45.$

$$f = \frac{75{,}000}{29.56} \pm \frac{132{,}100}{45}$$
$$= 2537 \pm 2935$$
$$= 5472 \text{ lb./sq. ft. leeward (compression)}$$
$$= -398 \text{ lb./sq. ft. windward (tension).}$$

The compression stress should not exceed the allowable compression for brickwork (or, in other cases, concrete or soil). If a small tensile stress occurs here, it will do no harm if it is kept below 20 lb. per sq. in. If tension cracks should occur, they would naturally develop around the whole periphery as the winds change their direction.

It must be pointed out that the equation,

$$f = \frac{P}{A} \pm \frac{M}{S}$$

is correct only for material which can take tension. If it is applied to material which cannot resist tension and tension should occur, a different method (to be shown later) should be used. The compressive value for f must be increased to make up for the disappearing or nonexisting tension value.

(1) Safety of Base on Soil (Fig. 4)

A solid rectangle or square is to be considered here, and if the load is in the center of the base (Fig. 5-*A*), the pressure is uniform all over. In this case it would be

$$\frac{113{,}000}{7.5} = 15{,}000 \text{ lb. for 1-ft. width.}$$

As the point of application, owing to the wind, moves away from the center, the soil pressure decreases on one side and increases on the other side (Fig. 5-*B*). The pressure diagram has changed from the rectangle to a trapezoid. The maximum soil pressure here is

$$p = \frac{\text{load}}{\text{area}} \pm \frac{\text{moment}}{\text{section modulus}}.$$

As the point of application approaches the limit of the middle third, the pressure on the opposite side decreases still more, and when the point of application reaches the middle third point, the pressure on the opposite side is zero and the trapezoid of the soil pressure becomes a triangle (Fig. 5-*C*).

Because the center of the soil pressure (reaction) must be in line with the load, the distance a represents one-third of the side of the triangle, or

a = distance from edge of footing to load.

The ordinate in line with the load is equal to the ordinate of a uniform pressure over the entire base of one-foot width as shown in *A*.

$$\text{Thus } \frac{113{,}000}{7.5 + 7.5} = 2050 \text{ lb.}$$

$$\frac{113{,}000}{7.5} = \text{load/sq. ft. of width for 7.5 ft. length.}$$

$$\text{Ordinate} = \text{load/ft. length.}$$

Thus p may be figured and the pressure triangle may be drawn.

To obtain compression only, the resultant pressure should intersect the bottom of the base within the middle third (other proof given herein), and the maximum pressure (if there is no tension) is obtained if the resultant passes through the edge of the middle third of the base and if the wind is at right angles to one side of the stack.

The center of the supporting pressure (reaction) must always be on the same vertical line as the point of application of the resultant. The vertical forces at this point are equal to each other. The horizontal force of the parallelogram, which is too small to shift the stack, is absorbed by the horizontal earth pressure.

The vertical force has been shown to establish the triangle (Fig. 5-*C*) with base b and depth p equal to the maximum compression in lb. per sq. ft. per ft. width (if working in feet), or p is equal to the maximum compression or fiber stress in lb. per sq. in. for this most remote fiber (if working in inches).

$$\text{Triangle } R = \frac{p \times 3a}{2}$$

$$\text{Therefore } p = \frac{2R}{3a}.$$

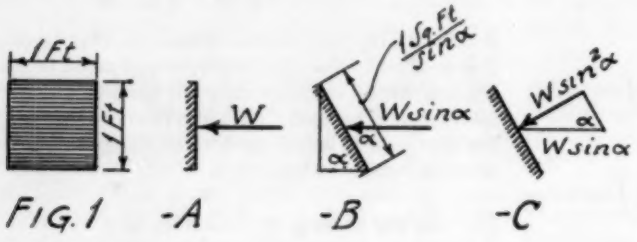


FIG. 1 -A -B -C

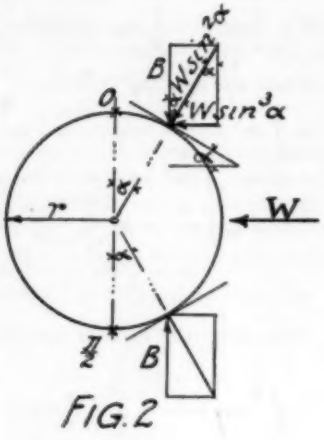


FIG. 2

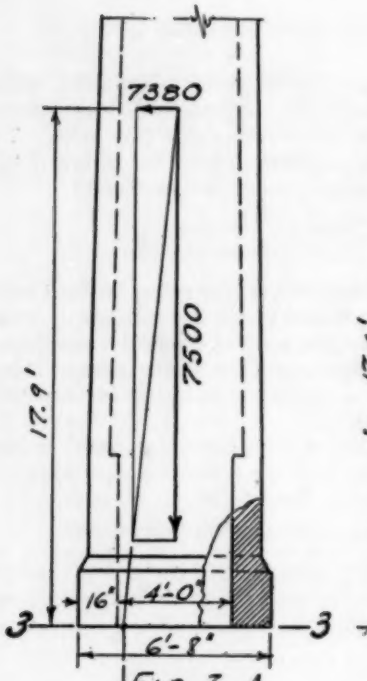


FIG. 3-A

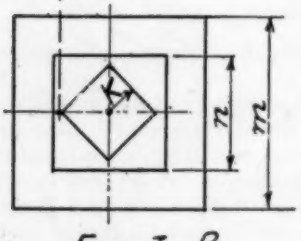


FIG. 3-B

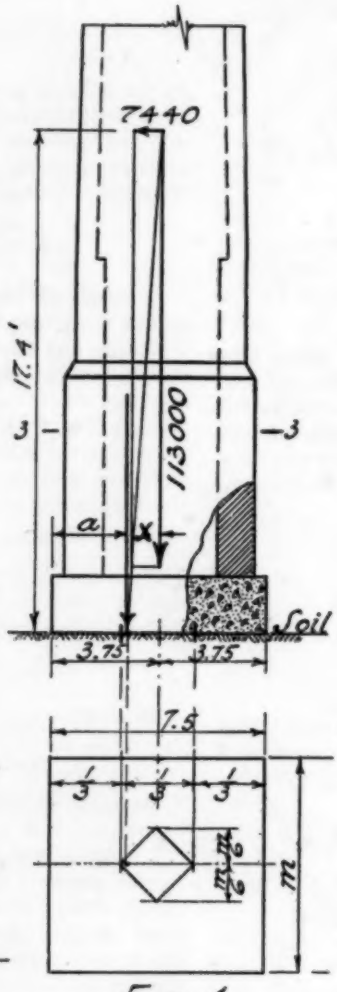
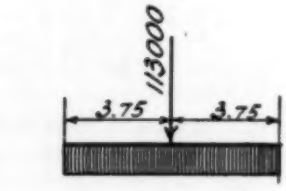
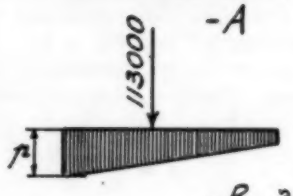


FIG 4



-A



-B

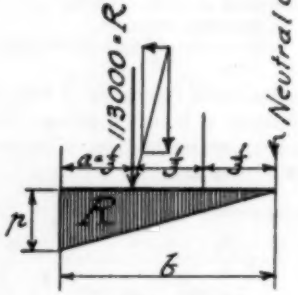


FIG 5-C

The same formula for p is obtained by making the proper substitutes in the formula for f (equation (3)) in reference to a solid square for M and S.

This formula for p is to be applied to the total stack and its action upon the soil. Thus the point of application of the resultant must first be located and brought within the middle third to avoid failure from tension. Soils of low-carrying capacity will not allow tension; variations in soil weakness must be considered in spite of soil tests, which, if done at all, are usually carried out in one place or over a small area.

This method obviously requires an accurate determination of the point of application of the resultant, but the graphic determination is usually not quite so accurate. The numerical determination, as applied to the stack (Fig. 4, elevation) is as follows

$$\frac{X}{17.4} = \frac{7{,}440}{113{,}000}.$$

$$\text{Therefore } X = \frac{7{,}440}{113{,}000} \times 17.4 = 1.15.$$

If 1.15 is deducted from one half of the base,
Then $a = 2.6$.
Total pressure along edge of base for width of 1 ft.

$$= \frac{2}{3} \times \frac{113{,}000}{2.6} = 29{,}000 \text{ lb.}$$

Width of base = 7.5 ft.
Maximum compression 29,000 ÷ 7.5 = 3860 lb./sq. ft.

The formula,

$$p = \frac{2}{3} \times \frac{P}{a},$$

is applicable only to a solid rectangle or square as a stack base but not to the hollow rectangular stack sections. For the latter, if there is no tension,

$$f \text{ or } p = \frac{P}{A} \pm \frac{M}{S}.$$

For the solid rectangle or square (as stack base), the following formula is often more convenient as the section modulus does not appear, viz.,

$$p = \frac{P}{A}\left(1 \pm \frac{6x}{b}\right).$$

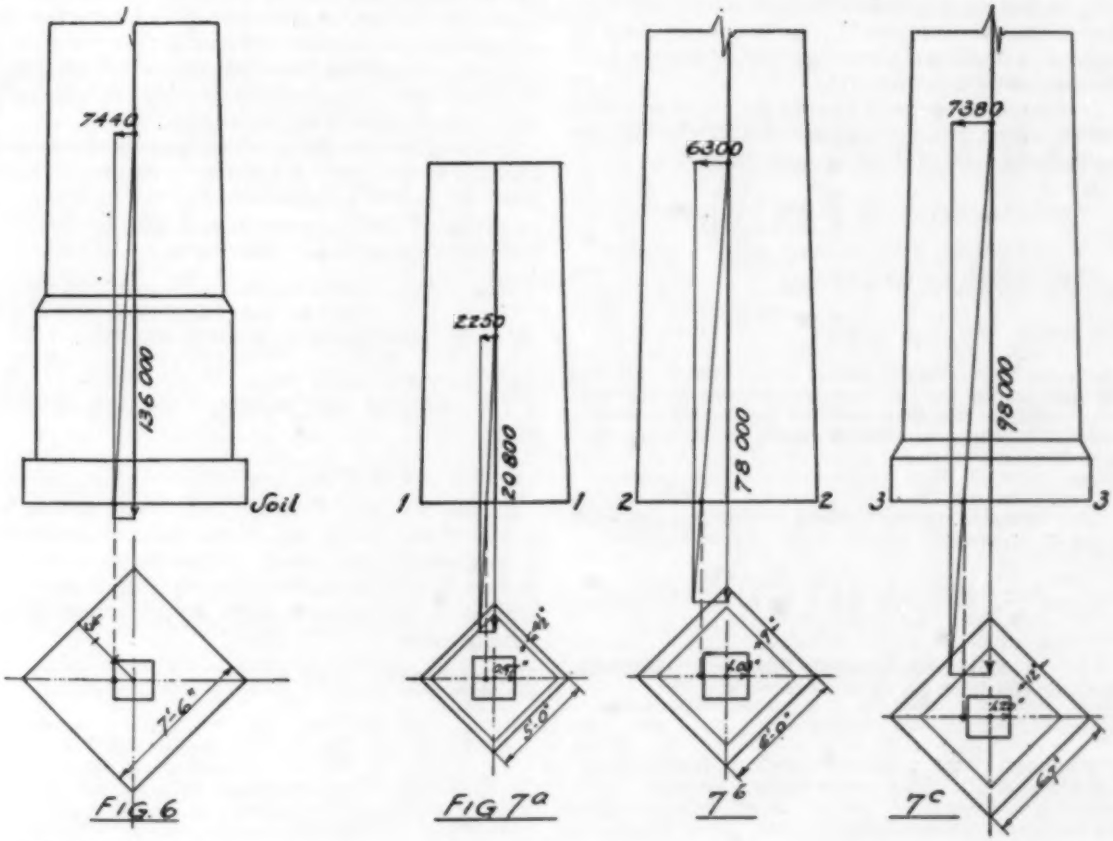
This has been derived from

$$p = \frac{P}{A} \pm \frac{M}{S},$$

$$= \frac{P}{A} \pm \frac{Px}{\frac{b^3}{6}},$$

$$= \frac{P}{A} \pm \frac{6Px}{b^3},$$

$$= \frac{P}{A}\left(1 \pm \frac{6x}{b}\right).$$



If the values of the stack are used in this formula, then

$$p = \frac{113{,}000}{7.5 \times 7.5}\left(1 \pm \frac{6 \times 1.15}{7.5}\right) = 3860 \text{ lb./sq. ft.}$$

III. Application of Kern Theorem

The "kern" theorem is presented as a graphic as well as a numerical method, applicable to the solid rectangle or square (base of stack) and to all the hollow squares of the stack sections. Only a brief explanation and the application of the theorem are given here.

Marks[2] states that "the kern is the area around the center of gravity of a cross section within which any load applied will produce stress of only one sign throughout the entire cross section. Outside the kern, a load produces stress of different sign."

As long as the neutral axis is located outside of a cross section, the stresses all over the section will be of one kind, either tension or compression. If, however, the neutral axis cuts through the section, the one part has compression and the other part tension. If the point of application of the stress or load coincides with the center of gravity, the neutral axis is located at infinity and the stress is uniform all over the section. Consequently, as the point of application moves away from the center of gravity, the neutral axis moves from infinity toward the section until it touches it or becomes a tangent. The points of application may be ascertained for all tangents; they form a closed curve or polygon, and the area inside this borderline is called the "kern" (German for "core"). As long as the point of application is within the kern there will be only one kind of stress (positive in this case).

To determine the size of kern for the hollow square of a stack section with the sides m and n, the formula for one-half of the side of the kern square is

$$k = 0.1179 \times m \left[1 + \left(\frac{n}{m}\right)^2\right].^*$$

* The equation for the solid square is

$$K = \frac{m}{6}\,\frac{1}{\sqrt{2}} = 0.1179\, m.$$

The value in brackets is always larger than 1; so that the solid section has the smallest kern, and as the walls become thinner the kern increases because the resisting material is being concentrated on the outside where it is most effective.

This formula, applied to stack section 3–3 (see Figs. 3 and 4), gives

$$k = 0.1179 \times 6.7 \left[1 + \left(\frac{4}{6.7}\right)^2\right] = 1.1.$$

This kern is shown in the plan of stack section 3–3 in Fig. 3-*B*. If the point of intersection of the resultant is projected with the base line (Fig. 3-*A*) into the plan, the point of application falls a little outside of the kern, which indicates some tension. This tension was noted previously for section 3–3 in section II (p. 154). There is no criticism of insufficient accuracy in this method because the numerical value of the distance from the center line to the outer point of the kern (being half the diagonal of the kern square) is quickly computed from the side of the kern square.

For the cross section of a solid square, the distance from the center line to the point of the kern square is equal to one-sixth of one-half of the base (Fig. 4). The projection of the point of application here falls within the kern so that no tension is encountered.

The tridivisional method of the base line presented in section II checks the kern method, inasmuch as the point of the kern is identical with the middle third (Fig. 4).

This method may be used to advantage for the solid square or stack base as well as for any hollow square, round, or octagon stack section with different corresponding formula.

IV. Use of Kern for Wind Blowing Diagonally Against Square Stack

The kern suggests an investigation of the wind at right angles to the diagonal of the square stack or an overturning at the edge of the stack. Conditions become worse in that the projection of the intersection (resultant force or diagonal with base line) or the point of application must now fall within one-half of the side of the kern square, whereas before it could fall within one-half of the diagonal of the kern square.

The weight of the lining, which has been disregarded, amounts to 136,000 − 113,000 lb. or nearly 500 lb. per linear ft., and in a consideration of the most extreme condition of loading, everything available should be taken into account; e.g., the weights are as follows:

Section 1–1: 12,800 + (16 × 500) = 20,800 lb.
" 2–2: 58,000 + (40 × 500) = 78,000 lb.
" 3–3: 75,000 + 23,000 = 98,000 lb.

The total stack on the soil is 136,000 pounds.

The horizontal wind pressure is the same as before, viz.,

$$2\,(w \sin^2\alpha) = 2\,(w \times 0.5) = w.$$

Section 1–1, Fig. 7[a] is safe, whereas in section 2–2 in Fig. 7[b] and 3–3 in Fig. 7[c], the point of application is just outside the kern. An intersection, however, slightly outside the kern, indicating a small amount of tension in the extreme fibers at the corner, is not objectionable.

314 King Avenue
Columbus, Ohio

[2] L. S. Marks, Mechanical Engineer's Handbook. McGraw-Hill Book Co., New York, N. Y.

CERAMIC ABSTRACTS

Compiled by the

AMERICAN CERAMIC SOCIETY

Ross C. PURDY, Editor

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May, 1940
19—5

Abrasives

Lapless gauges. H. J. WILLS. *Amer. Machinist*, **81**, 247 (March 24, 1937); *Metals & Alloys*, **8** [9] MA560 (1937).—W. describes a commercial process of finish-grinding by which the gauges or pieces to be finished to dimension are built up by Cr-plating and then ground in a single process on a recently developed Aloxite resinoid wheel, thus eliminating a series of wheels of progressively increasing fineness.

Preparation of corundum. B. GLEZIN. *Novosti Tekhniki*, **1937**, No. 12, p. 31; *Chem. Abs.*, **31**, 7207 (1937).—Al_2O_3 is melted with oxides of Ti and Cr. An addition of 5% TiO_2 increases the abrasive properties 30%, and an addition of 5% Cr_2O_3 increases tenacity.

Using abrasives in the foundry. B. N. HODGES. *Abrasive Ind.*, **17**, 16–19 (May, 1936); *Metals & Alloys*, **7** [11] MA537 (1936).

Wheels for carbide tools. E. T. LARSON. *Amer. Machinist*, **81**, 284–85 (April 7, 1937); *Metals & Alloys*, **8** [8] MA495 (1937).—The abrasives used on wheels for grinding cemented carbide tools are diamond or silicon carbides. A table shows the grade, grain size, and bond to be used for different grinding operations.

PATENTS

Abrasive article. A. L. BALL (Carborundum Co.). Can. 386,034, Jan. 2, 1940 (June 10, 1938). G.M.H.

Abrasive article production. E. S. MERRIAM. Can. 386,123, Jan. 9, 1940 (Nov. 29, 1938; in U. S. April 28, 1938). G.M.H.

Abrasive body. S. S. KISTLER (Norton Co.). Can. 386,354, Jan. 16, 1940 (May 25, 1937; in U. S. May 28, 1936). G.M.H.

Abrasive material. F. D. OESTERLE AND GEORGE ZELLAR (Western Electric Co., Inc.). U. S. 2,191,803, Feb. 27, 1940 (July 2, 1938).

Abrasive web coating apparatus. R. L. MELTON, R. C. BENNER, AND H. P. KIRCHNER (Carborundum Co.). Can. 386,398, Jan. 16, 1940 (March 15, 1935). G.M.H.

Automatic strip grinder. H. M. BROWN (International Nickel Co., Inc.). U. S. 2,191,814, Feb. 27, 1940 (Aug. 26, 1938).

Coated abrasive. N. E. OGLESBY (Behr-Manning Corp.). Can. 386,152, Jan. 9, 1940 (Oct. 16, 1937; in U. S. Feb. 6, 1937). Can. 386,299, Jan. 16, 1940 (Oct. 16, 1937; in U. S. Feb. 6, 1937). G.M.H.

Dressing grinding wheels. H. F. ATKINS. Brit. 517,824, Feb. 21, 1940 (Aug. 6, 1938).

Dressing grinding wheels having spiral ribs. H. F. ATKINS. Brit. 518,019, Feb. 28, 1940 (Aug. 6, 1938).

Grinder. L. J. WAHL. U. S. 2,191,600, Feb. 27, 1940 (Aug. 25, 1937).

Grinding, buffing, polishing, boring, and milling machines, etc. R. GRIEVING. Brit. 517,291, Feb. 7, 1940 (April 28, 1938).

Grinding machine. PAUL KOSTER. U. S. 2,191,617, Feb. 27, 1940 (May 11, 1938).—A machine for rectifying motor valve seats. ROBERT MCMILLEN. U. S. 2,192,981, March 12, 1940 (Aug. 24, 1938).—A sharpener for tools.

Grinding the relieved cutting teeth of screw-thread cutting mills. H. LINDNER. Brit. 517,657, Feb. 14, 1940 (May 5, 1938).

Grinding-wheel dresser. FRANK GREINER, C. L. OTT, AND R. E. PRICE (Landis Tool Co.). U. S. 2,192,308, March 5, 1940 (Jan. 8, 1937).

Hone. H. W. DUNBAR AND H. S. INDGE (Norton Co.). U. S. 2,191,256, Feb. 20, 1940 (April 28, 1938). S. E. ORDAL. U. S. 2,191,994, Feb. 27, 1940 (Feb. 7, 1938).

Honing device. MICROMATIC HONE CORP. Brit. 518,081, Feb. 28, 1940 (Aug. 13, 1937).

Manufacture of abrasive alumina. CHEMICAL CONSTRUCTION CORP. Brit. 517,858, Feb. 21, 1940 (Sept. 22, 1937).

Manufacture of abrasive articles. R. C. BENNER AND R. L. MELTON (Carborundum Co.). U. S. 2,193,265, March 12, 1940 (Sept. 1, 1937).—The method of manufacturing a metal bonded abrasive article comprises the

steps of spraying an unsized abrasive coated web with metal, peeling off the backing web, assembling successive layers of the metal bonded abrasive granules into the desired shape, and applying heat and pressure to compact the mass.

Polishing machines, etc. E. M. MORRIS. Brit. 518,083, Feb. 28, 1940 (Aug. 15, 1938).

Portable surfacing machine. E. B. GEORGE. U. S. 2,193,419, March 12, 1940 (June 27, 1938).

Process and apparatus for grinding tools. A. PFUNGST STIFTUNG. Brit. 518,026, Feb. 28, 1940 (Jan. 8, 1938).

Resurfacing machine. J. Y. BLAZEK AND V. R. ROY (Lempco Products, Inc.). U. S. 2,192,888, March 12, 1940 (Aug. 26, 1938).

Sharpening stone oiler and support. W. A. KUHLMAN. U. S. 2,191,719, Feb. 27, 1940 (Nov. 12, 1938).

Surface-broaching machine. WALTER FERRIS (Oilgear Co.). U. S. 2,190,642, Feb. 20, 1940 (June 26, 1937).

Surfacing machine. E. B. GEORGE. U. S. 2,193,418, March 12, 1940 (June 14, 1937).

Universal sharpener. ADAM PRIMAK. U. S. 2,191,899, Feb. 27, 1940 (Sept. 7, 1937).

Art and Archeology

Ancient Egyptian earthenware. H. DE MORANT. *Nature* [Paris], No. 3042, pp. 65–69 (1939).—M. describes the Egyptian ceramic industry in ancient times. See "Glass . . .," *Ceram. Abs.*, **17** [2] 62 (1938). R.W.D.

Athenian jugs. G. M. A. RICHTER. *Bull. Metropolitan Mus. Art*, **34** [10] 231–32 (1939).—Two Athenian red-figured jugs (late 5th century B.C.) are of the so-called chous shape, which was used during the three-day festival of the Anthesteria in honor of Dionysus. They are decorated with scenes connected with that festival. These two jugs may be associated with the Pithoigia or the Choes, both days of rejoicing. The Museum has other examples of jugs decorated with scenes connected with this festival including several miniature jugs probably used by children. A.A.A.

Athenian vases. G. M. A. RICHTER. *Bull. Metropolitan Mus. Art*, **35** [2] 36–40 (1940).—New acquisitions of terra-cotta Greek vases include the following: (1) A black-figured Athenian lekythos or oil jug is of a rare shape not hitherto represented in the Museum's collection. It is from the 6th century B.C. and is the earliest form of the Athenian lekythos. (2) A red-figured pyxis or kylichnis is an Athenian toilet box of the 5th century B.C. The scene painted on it may be the birth of Aphrodite. (3) A dainty Athenian cup in the form of a ram's head is from the second quarter of the 5th century B.C. The head is made from a two-piece mold but the mouth of the cup is thrown and turned on the wheel. (4) A large fragment of an Attic red-figured loutrophoros is decorated with a battle scene between Greek soldiers and Amazons, instead of the usual wedding or funeral scene. (5) A red-figured Athenian lekythos from about the same period represents an Amazon queen receiving a deathblow from a Greek soldier who suddenly becomes aware that he loves the one he has just fatally wounded. Besides these Attic vases, one of South Italian make is an example of the so-called Gnathian ware, one of many Hellenistic wares made in Italy during the 4th and 3rd centuries B.C. See *Ceram. Abs.*, **18** [9] 229 (1939). A.A.A.

Designing for glass. ANON. *Architectural Forum*, **72** [2] 12 (1940).—Three of the more successful designs resulting from the Steuben invitation to 27 artists are illustrated. They are by Jean Cocteau, Isamu Noguchi, and Christian Berard. M.E.P.

Early Greek art. G. M. A. RICHTER. *Bull. Metropolitan Mus. Art*, **34** [12] 286–88 (1939).—Besides the upper part of a bronze figure, the Museum has also acquired a terra-cotta ointment jug in the form of a young woman. It was made in a two-piece mold, probably in Rhodes in the early 6th century B.C. There are similar specimens in other museums, but this is the first owned by the Metropolitan. A.A.A.

Early Ming ware of Chingtehchen. FRANK DAVIS. *Illus. London News*, **104** [2699] 76 (1939).—The present methods of manufacture at Chingtehchen appear to be the same, in all essentials, as they were during the Ming dynasty. Illustrations show the forming of vessels, drying of bowls (a process which causes the vessel to lose all its plasticity and to have the consistency of short bread), glazing, and decorating with cobalt. The decorating process may be compared to writing in ink on blotting paper. L.F.M.

Gift of ceramics. C. LOUISE AVERY. *Bull. Metropolitan Mus. Art*, **35** [2] 45–46 (1940).—Among eight pieces recently presented to the Museum are a Worcester porcelain teapot with a green ground and exotic birds in medallions, an English lustered earthenware jug, a Lowestoft porcelain inkstand, and a French biscuit figure of a man. The four other pieces are of the so-called Chinese Lowestoft and include a plate picturing a Dutch ship, the Vryburg, with the name of her captain and the date of her visit to China inscribed thereon, a punch bowl with nautical scenes, a mug with Masonic emblems, and a plate with a scene of the Crucifixion. A.A.A.

Glass artist, Finsch, of Warmbrunn, a forgotten inventor. W. GANZENMÜLLER. *Glashütte*, **68** [28] 474–77 (1938).—Moritz Finsch of Silesia belonged to that group of forgotten glassmakers whose tireless research helped perfect the technique of glassmaking. For 23 years he directed a free drawing and cutting school for glass painters. In 1846 he began experimenting with the production of new kinds of glass. He attempted to reproduce an antique opaque red copper glass called by Pliny "haematinon" (blood color), and in 1866 he succeeded in obtaining an opaque red mass scarcely less beautiful in color than the antique glass. The glass was made harder and more resistant to firing by the addition of alumina and by being calcined at higher temperatures. Opacity was obtained by the addition of a small amount of kaolin or porcelain clay. Finsch studied the color variations obtained by copper in its different stages of oxidation and when combined with other metals. He experimented with the use of kieselguhr in the production of glass for artificial topaz, but the iron oxide in the kieselguhr and the necessity for high temperatures to eliminate bubbles and spots were handicaps. M.V.C.

Late English pottery. FRANK DAVIS. *Illus. London News*, **103** [2696] 1214 (1938).—Eighteenth-century English pottery cannot be compared with Dresden or Chelsea porcelain. What the Staffordshire pottery lacks in gentility it makes up in vigor. Jugs and figures are illustrated. L.F.M.

Liverpool pitcher of James Lawrence. HELEN COMSTOCK. *Connoisseur*, **104** [459] 248 (1939).—The portrait on this pitcher was taken from the stipple engraving done in Boston by Stuart in 1812. It is from the collection of the Rhode Island School of Design. Its shape is not the customary barrel design. An earlier shape, like an inverted pear, was used for the Washington pitcher of which it is said that many were broken to enhance their value. All of the Liverpool pitchers of illustrious subjects are excellent. Illustrated. M.E.P.

Metallic luster in glost firing. L. V. L. NARASINGHA RAO. *Indian Ceramics*, **1** [3] 90–91 (1938).—When glost firing ordinary earthenware bodies with a black glaze designed to mature at 980°C., R. found that the ware had a bright metallic luster which greatly enhanced its commercial value. A close examination of the muffle revealed a fine crack at the bottom of the muffle, which was left open. Experiments showed that the metallic color was caused by the coal gases entering the muffle. The change was purely a physical one brought about by the smoke acting upon the molten glaze when the glaze was fully matured. The intensity of the metallic luster varied

inversely with the intensity of the smoke action. See *Ceram. Abs.*, **19** [2] 39 (1940). A.P.S.

Recent gifts for the American Wing. M. B. D. *Bull. Metropolitan Mus. Art*, **34** [11] 265–66 (1939).—Two fine pieces of early American pottery are a large octagonal covered jar with a rich flint-enamel glaze, which typifies the ware made at Bennington, Vt., and a large jug of red earthenware with somber brownish glaze not quite covering the exterior. The sturdy, practical form of simple design is characteristic of the ware made for domestic use. See *Ceram. Abs.*, **18** [9] 231 (1939). A.A.A.

Turkish peasant pottery from Chanak and Kütahya. Arthur Lane. *Connoisseur*, **104** [459] 232–37 (1939).—Of coarse red clay painted with earthy pigments of blue, brown, white, dull yellow, or vermilion-red, usually over white slip, the Chanak ware is true peasant ware. Its unsophisticated simplicity and balance of shape and decoration make it comparable to the Sung ware of China. Because much of it has been found in Aegean countries, it was formerly attributed to that locale but is now accepted to be of Chanak origin. The Kütahyan ware is the decadent tradition of the fine Rhodian ware of the 16th and 17th centuries. The Rhodian ware was made at Isnik, and the potters drew most of their profits from painted tile which was exported throughout the Turkish Empire from Constantinople to Egypt. When building activity grew less at the end of the 17th century, the pottery industry lost its importance to the Turkish rulers. The craftsmen, who were mainly Armenians, Persians, and Greeks, began to suit their own tastes, and their effort to support themselves in the declining art brought many outside influences into their decorations. Much of this ware made at Kütahya was used to decorate the Armenian churches. The blue-painted tile were used as altar facings. The pierced egg-shaped pieces painted with cherubs' heads were strung on chains to support hanging lamps. The best of this work was done during the 18th century. Illustrated. M.E.P.

Wood's 18th-century pottery. Frank Davis. *Illus. London News*, **104** [2704] 264 (1939).—By first dipping the figure in the creamy white glaze and then painting with enamel colors, a porcelain appearance was produced by Ralph Wood, Jr. A wide color range, especially in the various shades of red, was possible. Illustrated. L.F.M.

Worcester porcelain: Lockwood collection. C. Louise Avery. *Bull. Metropolitan Mus. Art*, **35** [1] 4–8 (1940).—The Museum has recently received the Lockwood collection of 159 examples of Worcester porcelain, which were chosen with the idea of enriching and completing the collection already owned by the Museum. The examples were chosen from the many patterns made during the best period of the factory, from its establishment in 1751 by John Wall and his associates until it was purchased by Thomas Flight in 1783, when the character of the ware changed considerably, becoming more severe, formal, and pretentious. Worcester potters modified and blended patterns of Sèvres and Meissen ware to conform to their conservative clientele. While not original in design, their porcelain was developed into a very fine ware. They developed transfer printing to an exceptional degree, the Worcester glazes taking the printing without blurring. In this collection there are portrait busts of Queen Charlotte and Frederick the Great and scenes from paintings by Watteau, Boucher, and Gainsborough. Worcester borrowed extensively from Oriental designs, either directly from a Chinese or Japanese model or from a Meissen or Chelsea copy. The use of flowers and fruit, bright birds (some on colored grounds), basket patterns, and other decorations, Worcester borrowed from Meissen and also imitated some of the colored grounds of Sèvres. A large covered vase with scale-blue ground broken by reserves enclosing fantastic birds and bordered by scrolls in the soft-toned gilding for which the factory was renowned is the most imposing piece in the Lockwood collection. A.A.A.

BOOKS

Anatolian Studies Presented to William Hepburn Buckler. Edited by W. M. Calder and Josef Keil. Manchester University Press. Price 25s. Reviewed in *Times Lit. Supp.*, **39** [1982] 51 (1940).—This is a collection of twenty-six papers by distinguished contributors covering all fields of Anatolian archeology. Illustrated. K.W.W.B.

Monumenta Asiae Minoris Antiqua: Vol. 6. Edited by W. H. Buckler and W. M. Calder. Manchester University Press. Price 40s. Reviewed in *Times Lit. Supp.*, **39** [1983] 63 (1940).—The sites concerned in this volume are Laodikeia, Kolossai, Tripolis, Trapezopolis, Attouda, Herakleia, Apollonia, Tabai, Apameia, Akmonia, Diokleia, and Synnada. Items from the Upper Tembris Valley and certain monuments now collected at Afyon Karahisar are also included. Illustrated. K.W.W.B.

Tell el-Amarna Tablets. Edited by Samuel A. B. Mercer and Frank Hudson Hallock. Macmillan Co., London, 1940. 2 vols. Price 84s. Reviewed in *Times Lit. Supp.*, **39** [1985] 91 (1940).—This is a new translation and transcription; texts previously available only in certain periodicals are included. K.W.W.B.

Temple of Hibis in El Khârgeh Oasis: II. Edited by H. G. Evelyn White and James H. Oliver. Metropolitan Museum of Art, New York. Price $3.50. Reviewed in *Times Lit. Supp.*, **39** [1983] 63 (1940).—The epigraphical results of the work undertaken on the site by the editors for the Metropolitan Museum of Art during the years 1909 to 1913 are presented. Illustrated. K.W.W.B.

Topographical Bibliography of Ancient Egyptian Hieroglyphic Texts, Reliefs, and Paintings: VI, Upper Egypt: Chief Temples (excluding Thebes). Bertha Porter and Rosalind L. B. Moss. Clarendon Press, Oxford; Milford, London. Price 35s. Reviewed in *Times Lit. Supp.*, **39** [1984] 79 (1940).—Illustrated. K.W.W.B.

PATENTS

Article-decorating apparatus. David Denelsbeck (Owens-Illinois Glass Co.). Can. 386,358, Jan. 16, 1940 (Oct. 12, 1937). G.M.H.

Designs for:

Bottle. W. R. Leach. U. S. 119,088 and 119,089, Feb. 20, 1940 (Nov. 15, 1939).

Bowl. R. A. May (Duncan & Miller Glass Co.). U. S. 119,279, March 5, 1940 (Dec. 21, 1939).

Dish. J. E. Spence (Hazel-Atlas Glass Co.). U. S. 119,403, March 12, 1940 (Dec. 18, 1939).

Jelly tumbler. W. J. Lundy (Olean Glass Co.). U. S. 119,393, March 12, 1940 (Jan. 18, 1940).

Plate. C. W. Leigh (Morimura Bros., Inc.). U. S. 119,270 to 119,274, March 5, 1940 (Jan. 26, 1940).

Tumbler. R. A. May (Duncan & Miller Glass Co.). U. S. 119,278 and 119,280, March 5, 1940 (Dec. 21, 1939).

Whiskey flask. D. E. Briner (Ball Bros. Co.). U. S. 119,202, Feb. 27, 1940 (Nov. 24, 1939).

Cements

Behavior of slag glasses in the presence of ammoniac and amine salts of organic acids. F. Keil and F. Gille. *Zement*, **28** [28] 429–34 (1939).—The behavior of slag glasses in the presence of slightly basic or slightly acidic solutions is variable and depends on the solubility of the glass oxides for a given pH. These solutions attack the crystalline components of cement clinkers differently. The separation of crystalline MgO, amorphous SiO_2, aluminate, and aluminoferrite is possible. The differences in solubility permit the separation, when nonhydrated, of alumina and slag cement, alumina and Portland cement, and Portland and slag cement. It is possible to deter-

mine clinker, blast-furnace slag, and alumina cement glass in a mixture. If limestone and trass are added to concrete, the determination of the components remains possible. F.E.V.

Constitution of Portland cement: IV. K. Kovanagi and T. Sudoh. *Zement*, **28** [37] 563–68 (1939).—Synthetic specimens of $3CaO \cdot SiO_2$, prepared differently, were found to be identical. Alite and pure $3CaO \cdot SiO_2$ are different. All possible mix crystals of $3CaO \cdot SiO_2$ with other components of clinker were studied; $3CaO \cdot SiO_2$ gives a mix crystal with a small content of MgO and $3CaO \cdot Al_2O_3$; this is alite. The silicate retains 1.0 to 1.5% MgO in solid solution in its crystal lattice. The microscopical examination of alite shows a zone structure and the mix crystallization. For Part III see *Ceram. Abs.*, **18** [5] 121 (1939). F.E.V.

Developments in cement firing. H. Jordan. *Zement*, **28** [34] 524–28; [35] 540–42 (1939).—German patents of 1937 and 1938 are described. Illustrated. F.E.V.

Direct method for the determination of aluminum in Portland cement. W. R. Chandler. *Rock Products*, **39** [8] 52–54 (1936); *Chem. Abs.*, **30**, 7810 (1936).—C. describes a gravimetric 6-hydroxyquinoline method and a thiosulfate titration method.

Heat of hydration of calcium sulfates. J. C. Southard. *Ind. Eng. Chem.*, **32** [3] 442–45 (1940).—The heats of the following reactions involving water and the various forms of calcium sulfates have been determined calorimetrically by solution in hydrochloric acid and in part by direct hydration:

$$CaSO_4 \cdot {}^1/_2H_2O_{(\text{stable crystalline})} + {}^1/_2H_2O = CaSO_4 \cdot 2H_2O_{(\text{solid})} \quad \Delta H_{298} = -4100 \pm 20 \text{ cal./gm. f. w.}$$

$$CaSO_4 \cdot {}^1/_2H_2O_{(\text{metastable})} + {}^1/_2H_2O = CaSO_4 \cdot 2H_2O_{(\text{solid})} \quad \Delta H_{298} = -4600 \pm 20 \text{ cal./gm. f. w.}$$

$$CaSO_{4(\text{soluble anhydrite})} + 2H_2O = CaSO_4 \cdot 2H_2O_{(\text{solid})} \quad \Delta H_{298} = -7210 \pm 10 \text{ cal./gm. f. w.}$$

$$CaSO_{4(\text{natural anhydrite})} + 2H_2O = CaSO_4 \cdot 2H_2O_{(\text{solid})} \quad \Delta H_{298} = -4040 \pm 20 \text{ cal./gm. f. w.}$$

Heat-of-solution measurements indicate that commercial hard wall plaster is a mixture of the stable and metastable hemihydrates and that casting plaster is composed almost entirely of the stable crystalline form. Illustrated. F.G.H.

Influence of catalysts in the production of high-strength cements. W. Watson and Q. L. Craddock. *Cement & Cement Manuf.*, **9**, 13–19 (1936); *Chem. Abs.*, **30**, 4641 (1936).—The effect of clinker cooling is important in improving cement quality. CaF_2 (1 to 3%) lowers the clinkering temperature and has no detrimental effect on strength, but the life of the kiln lining may be shortened. Borax and alkalis produce a more vitreous clinker but do not improve strength. Alkali above 1% is detrimental to soundness. $CaCl_2$(1 to 2%) ground with clinker accelerates hardening and the rate of increase in strength. Curing of the concrete surface with $CaCl_2$ yields similar results. Other metal chlorides (except those of heavy metals) are in general beneficial. The addition of NaCl together with $Al_2(SO_4)_3$ has been patented, and $NaSO_3$ and Na_2SO_4 have been advocated for the improvement of early concrete strength. Test pieces mixed with and stored in alkali phosphate solutions showed greater strength than those mixed with pure H_2O. Hydrated lime improves workability. In general, no great improvement has been made by the addition of materials after grinding.

Inversion of dicalcium silicate. Seiji Kondo, Toshiyoshi Yamauchi, and Mititane Oki. *Jour. Japan. Ceram. Assn.*, **47** [554] 76–81 (1939).—A study was made of the inversion of dicalcium silicate ($2CaO \cdot SiO_2$). Specimens were prepared by heating a mixture of C.P. $2CaCO_3 + SiO_2$ for 2 to 8 hr. at temperatures ranging from 1400° to 1700°C. They were quenched in ice-cold mercury and examined for microstructure, X-ray diffraction, thermal changes, etc., with the following results: (1) Specimens heated at 1500° and higher dusted less than those prepared at lower temperatures. All specimens quenched in an ice-cold Pt crucible or in similar manner were mixtures of α- and β-$2CaO \cdot SiO_2$. (2) When the temperatures were raised gradually above 1500°, the products quenched as above were poorer in γ modification and richer in α modification, almost pure α-$2CaO \cdot SiO_2$ being obtained at about 1700°. (3) When cooled naturally, the products always contained the α form. (4) Pure γ-$2CaO \cdot SiO_2$ can be obtained from its mixture with the α form by sieving the products to collect the dusted powder, by reheating the products for a long time at temperatures wherein the γ form is stable (over 300 hr. at 550°), and by dissolving the α form off with water. (5) In thermal analysis, γ-$2CaO \cdot SiO_2$ indicated a strong endothermic reaction at $720 \pm 5°$ in heating up and a strong exothermic reaction at $690 \pm 5°$ in cooling down. These changes are probably due to γ–β inversion. Alpha-$2CaO \cdot SiO_2$ and $3CaO \cdot 2SiO_2$ showed slight exothermal changes at temperatures between 600° and 700°; they are probably caused by the γ–β inversion of the γ-$2CaO \cdot SiO_2$ contaminated in the specimens. (6) It may be concluded that α–β and α–γ transformations of $2CaO \cdot SiO_2$ are sluggish inversions while β–γ changes are rapid and are therefore high-low inversions. (7) Synthetic tricalcium silicate probably contains some γ-$2CaO \cdot SiO_2$. Further investigation is necessary to determine whether or not $3CaO \cdot 2SiO_2$ exists. S.K.

Supermicroscopic examination of lime hydration. O. E. Radczewski, H. O. Müller, and W. Eitel. *Zement*, **28** [49] 693–97 (1939).—CaO and $Ca(OH)_2$ obtained by different processes, including the action of water on cement, were examined with the Siemens electronic microscope. The size and the appearance of the particles are described. Illustrated. F.E.V.

White Portland cement. P. Bozhenov. *Tsement*, **5** [1] 35–42 (1937); *Chem. Abs.*, **31**, 4469 (1937).—Raw materials assuring a content under 0.45% of Fe_2O_3 and under 0.5% of TiO_2 in the clinker can be used. Porcelain kilns with a basic lining can be most expediently used for burning the clinker. The raw materials and clinker must be ground in mills with porcelain or silicate lining and with filling bodies of the same material. Bauxite white slurry obtained as a by-product in the production of Al_2O_3 can be used as a raw material.

X-ray study of Japanese Portland-cement clinkers: I. S. Kondo and T. Yamauchi. *Jour. Japan. Ceram. Assn.*, **44**, 628–45 (1936); *Chem. Abs.*, **32**, 2310 (1938).—The mineral constitution was the same for clinkers made by the wet and the dry processes. The principal component was $3CaO \cdot SiO_2$; $2CaO \cdot SiO_2$ was the only other compound recognized.

Enamel

Acid- and alkali-resistant finishes. A. O. Plambeck. *Metal Cleaning & Finishing*, **8**, 191–94, 202 (1936); *Chem. Abs.*, **30**, 5380 (1936).

Aspects of the scumming problem. G. H. Spencer-Strong and L. J. McMahon. *Jour. Amer. Ceram. Soc.*, **23** [4] 102–107 (1940).

Bibliography on corrosion-resisting cast iron with special reference to chemical attack. G. R. Woodward. *Bull. Brit. Cast Iron Research Assn.*, **5**, 344–54 (1939).—W. presents 78 references to the literature on the corrosion of cast iron. The references are selected from British, French, German, and American publications. In most cases, W. gives a brief summary of the paper and, where a translation has been published, a cross reference to it. A.P.S.

Blistering in sheet cover-coat enamels. C. D. Clawson. *Enamelist*, **16** [3] 5–8 (1938).—C. describes types of blisters sometimes called viscous blisters or glass-eye boil.

Such isolated blisters are not confined to any particular enamels or enamel irons. Causes and the possible elimination of these defects are discussed. L.E.T.

Cloisonné making in China. MARVIN O. LEWIS. *Enamelist*, **17** [3] 30–32 (1939).—The ancient art of making Chinese cloisonné vases and bowls is described. The vases are first fashioned in copper; the cloisonnés are made of fine flattened copper wire or sometimes of gold or silver. The enamel frits are essentially colored high-lead glasses. The steps of manufacture and the kilns are shown in 8 illustrations. L.E.T.

Control of enamel slips. R. E. VIDAL. *Enamelist*, **16** [11] 11–15 (1939).—Elementary factors in the control of enamel slips are discussed. The roles of clay and bentonite as suspension agents and of electrolytes and acids as setting-up agents are outlined. The hardness of water is important, and adjustments or replacements with distilled or rain water are often advisable. Proper loading of the mills and controlled grinding time of the enamel slip are necessary. Slips should be aged for 24 to 48 hr. after milling. The control of the water content and cleanliness of mills, mill room, and storage containers are emphasized. L.E.T.

Developments in ground-coat enamels. J. E. ROSENBERG. *Ceram. Ind.*, **34** [3] 44, 46–47 (1940).—The use of thinner applications of cover-coat enamels has shown the need for more perfect ground coats. Ground coat is defined as an enamel which can be applied directly to iron and which will adhere and produce a good bond. In addition, it must be a satisfactory base coat for the application of subsequent coats of enamel and must fire at a relatively higher temperature than the cover coat, particularly because of the tendency of ground-coat enamels to reboil in the early stages of cover-coat fire. The development of the continuous furnace made necessary the development of different ground coats, and one hard and one soft ground-coat frit were blended to work together. The use of thinner applications of cover coat made defects in ground coats more serious; many have been overcome. Reboiling is seldom observed; R. describes this phenomenon in detail. Common enamel defects are described, including fish scales, shiners, copperheading, and burning off at the edges, and their causes are explained. Applications of ground coat should be as thin as possible, depending upon its ability to drain properly and the danger of burning off. The firing range should be at least 500 °F. Draining is determined by proper setting up of the enamel, of which mill additions are a factor. Mill additions should not be made indiscriminately to ground coats formulated to work without them; it is a mistake to assume that they always reduce costs. A new series of ground coats is described, in which the large addition of milling compound used is part of the frit formula. L.M.C.

Electric furnace in the porcelain enameling industry. H. J. BABCOCK. *Enamelist*, **16** [2] 18–25 (1938).—B. discusses the use of electric furnaces for firing porcelain enamel on sheet steel or iron and cast iron and the various designs of box-type and U-shaped continuous conveyer furnaces; data on the fuel oil or electric energy consumed by such furnaces are given. 6 illustrations, 6 diagrams. L.E.T.

Enamels with low boric acid content. ALDINGER. *Glashütte*, **69** [48] 797–99 (1939).—The boric acid content of most enamels could be reduced one half without materially affecting their properties. In many cases borax can be eliminated entirely, but the resulting enamels possess different properties and require special preparation. Enamels with little or no borax can be obtained by (1) the substitution of other fluxes partly or entirely, or (2) partial or complete replacement of the refractory materials, feldspar and quartz, by other more easily fusible natural or artificial silicates or silicate mixes; a combination of these two methods brings the quickest results. No other single flux possesses all the properties of borax; to obtain a similar effect, therefore, a combination of fluxes is required. The alkali content in borax may be supplied by soda. The alkali content in soda, potash, or lithium oxide can be raised as high as the expansion of the enamel permits. Besides the alkalis, fluorspar is used; 20% and more for ground enamels and up to 15% for coat enamels give good results in some cases. Cryolite and sodium fluosilicate can be used only sparingly in coat enamels because they increase the expansion of the enamel. Barium compounds (carbonate and nitrate) and strontium compounds are important in ground and coat enamels not destined for kitchen use. Zinc oxide is an important flux for ground and coat enamels not to be used for kitchen ware or drinking or eating utensils where no flux has been found to replace boric acid. Artificial silicates (soda and potash water glass) with a low fusing point can be used in place of these fluxes in the manufacture of enamels; these specially prepared substitutes are made on the same principle as the low borax or borax-free enamels, employing the same flux, and they offer a simple solution to plants which do not make their own tests. The boric acid content may be reduced by replacing the refractory quartz and feldspar by more easily fusible minerals, e.g., different kinds of phonolite, artificial silicate mixtures such as blast-furnace slag or water glass, and, chiefly, tested powdered glass of all kinds and compositions (untested powdered glass will cause fewer defects than other untested substitutes). Increasing the alkali content raises the expansion figure and will cause crazing. New batches should be tested on suitable objects which show the behavior of the enamel on edges and rims and the effect of sharp and weak firing. Much time can be saved in the tests by mixing two enamels: (1) an enamel containing the usual amount of boric acid and (2) an enamel with little or no borax (different proportions for different purposes). The following ground enamel with a low borax content can be used as a starting point in tests: quartz 15 parts by weight, feldspar 32, barium carbonate 5, zinc oxide 4, fluorspar 16, borax 10, soda 16, soda saltpeter 2, cobalt oxide 0.3, and nickel oxide 0.3; mill batch: granules 100, fluorspar 10 to 15, clay 10, borax 1, and soda 1. Good results can be obtained with these enamels only if special precautions are taken with pickling, grinding fineness, water content (the thinner the coat, the better), firing time, and temperature. The batch compositions of other ground and coat enamels with low borax content are given. M.V.C.

Essential factors of cast iron for porcelain enameling. A. S. HAWTIN. *Enamelist*, **16** [9] 11–17 (1939).—H. deals with irons and the direct application of leadless-type enamels to these irons. No ground coat is used, and all castings are annealed and steel grit-blasted. This is standard practice in England. 8 photomicrographs. L.E.T.

Experiments on ground-coat enamels. H. N. BOSE AND I. S. KALRAH. *Indian Ceramics*, **1** [3] 92–99 (1938).—Experiments were carried out with the purpose of producing good ground-coat enamels using the raw materials available in India: feldspar and quartz from Ajmere, commercial soda ash, and borax. The feldspar had the following composition: SiO_2 64.28, Al_2O_3 21.33, Fe_2O_3 0.05, CaO 0.14, MgO 0.16, K_2O 11.33, Na_2O 2.28, and loss 0.08% (total 99.65%). The borax, soda ash, and quartz were nearly pure. The raw materials were finely powdered, properly mixed, and passed through a 40-mesh sieve three times. The trials were made according to the proportions shown in Fig. 1. Each batch was mixed with CoO_2 0.3 gm., NiO_2 0.2 gm., and MnO_2 0.5 gm. before fritting. Each frit was ground with 5% white china clay and 30% water and subsequently sieved through an 80-mesh sieve before use. The diagram apex *Q* represents 50% quartz, and its base represents 25% quartz only, *Q* showing 5% less each step downward until the point *S* is reached which shows no quartz. Similarly, the apices *B*, *S*, and *F* represent 50% borax, soda ash, and feldspar, respectively, the total amount being 100 in each. Cross points are numbered 1, 2, 3, etc. There are 36 such numbers or trials. The range for quartz is 50 to 25%, for feldspar 50 to 0%, for borax 50 to 0%, and for soda ash 25 to 0%. Area I represents enamels almost flawless. Area II represents enamels which are very hard but have no other defect. III represents enamels which show a peculiar defect of a round patch mark with a pinhole at

the middle of each patch. The enamels are easily fusible. IV represents enamels with very low fusibility showing minute pinholes. V gives hard enamels with bad cases of fish scales in the lower regions and blistering in the upper portions. VI produces hard enamels developing blisters which subsequently chip off with a round patch.

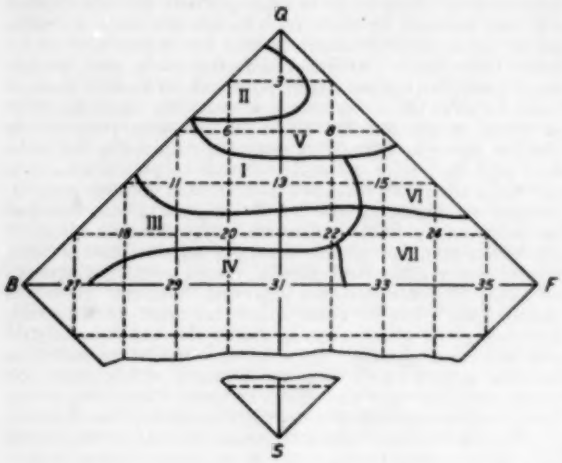

FIG. 1.

VII produces hard enamels with blisters, bad pinholes, dry spots, and chipping in the extreme end area. Conclusions are as follows: (1) (Feldspar and quartz) should not be below 50; otherwise pinholes are produced. The effects of feldspar and quartz are the same in this respect. When the content is below 50, pinholes appear on low firing but smooth out on hard firing; in this case burned edges may be expected. (2) (Feldspar and quartz) should not be more than 60 as burned points may come out of the pinholes. (3) When they are above 60, fish scales occur; these can be removed by the adjustment of borax and soda. (4) When silica and soda are constant, an increase of feldspar at the cost of borax develops bad pinholes and big blisters. (5) When feldspar and borax are constant, an increase of quartz at the cost of soda develops blisters. (6) When (feldspar and quartz) are constant, an increase of soda at the cost of borax develops blisters. Another trial as a derivative of No. 6 was made, replacing 5% borax by the same amount of soda. Fish scaling was removed, thereby confirming conclusion No. 3. A.P.S.

Flow test for porcelain enamels to be sprayed. JACK E. TREES. *Enamelist*, **16** [4] 28–31 (1939).—T. describes an apparatus which is a miniature reproduction of all essential working parts of a spray-pressure can and gun nozzle. It is used to test the rate of flow with a carefully controlled air pressure. The determination of the specific gravity of the enamel slip only measures the water content but takes no account of the spraying qualities and the set. With this apparatus, all such information is obtained. L.E.T.

Ground-coat water-content control. JACK E. TREES. *Enamelist*, **15** [10] 10–12 (1938).—Factors influencing a successful ground coat dipping operation, such as proper set, correct water content, amount of soluble salts, etc., are discussed. The water content may be determined (1) from the loss of moisture in the drying of a dipped test plate, (2) from the specific gravity of the enamel slip, or (3) by evaporating a sample of the wet slip. A comparison of the three methods on a slip with varying water content is shown in a table. The evaporation of a sample is the most simple and accurate method for checking the water content. L.E.T.

One-piece wrap-around stoves. E. A. LINDEMANN. *Ceram. Ind.*, **34** [3] 30–31 (1940).—One-piece construction of porcelain enameled stoves was not practical until continuous furnaces were developed and gradual heating and cooling were made possible. The A. J. Lindemann & Hoverson Co. prefers wrap-around body construction because of factory advantages as well as sales advantages. L. gives cost comparisons between wrap-around and built-up bodies, showing that the actual cost of wrap-around construction is somewhat lower than that of assembled construction and about the same as that of frame construction. The use of one-piece construction decreases indirect costs (trucking, storage of parts, etc.), increases durability, and lessens sales effort required, thereby reducing sales costs and increasing volume. Illustrated. L.M.C.

Phosphorus steels for vitreous enameling. C. H. LORIG AND D. E. KRAUSE. *Jour. Amer. Ceram. Soc.*, **23** [4] 107–10 (1940).

Preventing loss of raw materials and enamel. RICHARD ALDINGER. *Glashütte*, **69** [35] 617–20 (1939).—The loss of enamel in plants may be due to poor arrangement or to unnecessary distance between storage compartments, mills, and furnace; carelessness in conveying materials and emptying containers or damaged containers; the washing away of enamel granules with the quenching water; incomplete emptying of the mill before washing when different enamels are ground in the same mill; and ineffective means of salvaging enamel during coating. To determine how great a loss is sustained, certain precautions are necessary: The weight of all raw materials should be checked when received and also when used. By weighing the ware before and after enameling, the weight of the fired enamel can be determined (the loss by firing differs for different compositions but can be calculated). Exact figures for the raw materials received and the enamel granules obtained from them should be kept. If the loss exceeds 10%, a careful survey of each branch of manufacture should be made to find where losses are greatest; by small changes in the working methods or improvements in apparatus, losses can often be greatly diminished, or waste enamel can be recovered. M.V.C.

Properties of enamel slurry: I, Secondary fluidity and thixotropy. K. AZAROV AND N. SERDYUKOVA. *Zhur. Priklad. Khim.*, **10**, 1894–1903 (1937); *Chem. Abs.*, **32**, 2306 (1938).—The cause of "secondary draining" may be an excessive alkalinity of the slip caused by the solubility of the frit or by the amounts of added electrolytes. The high alkalinity causes an increase in mobility and in the tendency to the "reversible thickening" phenomenon. The velocity and degree of the latter depend on the amount of electrolytes in the slip. 18 references. For Part II see *Ceram. Abs.*, **18** [1] 12 (1939).

Proposed British Standard test for acid-resistance of enamels. ANON. *Chem. Trade Jour.*, **105**, 424 (1939).—A subcommittee of the Joint Committee on Vitreous Enamelling has issued for consideration a test for acid resistance. A solution (40 cc.) of oxalic acid (30 gm. crystalline acid per liter) is poured into an enameled basin of such a shape that 50 sq. cm. are covered. After being heated for 1 hr. on a water bath, the solution and washings from the basin are evaporated to dryness and ignited. A blank test on the oxalic acid should give no residue. The loss in weight of the basin is also determined. The amount of attack of the hot oxalic acid solution on the enamel is expressed as the amount dissolved in milligrams per square decimeter. L.R.B.

Relation of particle size and characteristics of light reflected from porcelain enamel surfaces. C. H. ZWERMANN AND A. I. ANDREWS. *Jour. Amer. Ceram. Soc.*, **23** [4] 93–102 (1940).

Stabilized recoat enamel. B. J. SWEO AND M. J. BAHNSEN. *Enamelist*, **16** [1] 5–12 (1938).—In the manufacture of white porcelain enameled ware, variation in color is encountered because of differences in thickness of the finish-coat enamel. Attempts have been made to minimize the color and reflectance difference between the normal and recoated ware by the use of tinted enamel for reoperation work, but without much success. A stabilizing oxide (Stabilite), added as a mill addition of 2% in

recoat enamel, has been developed. The principles on which Stabilite is based and the results of a series of tests are described. 7 diagrams. See *Ceram. Abs.*, **17** [9] 301 (1938). L.E.T.

Use of less familiar elements in porcelain enamel frits. G. H. McIntyre. *Enamelist*, **15** [12] 20–23 (1938).—From 80 to 85% of the enamel glass is composed of the familiar elements, chiefly sodium, oxygen, boron, and silicon with potassium, aluminum, calcium, and zinc present in lesser amounts or not at all. Among the less familiar elements used are lithium, cadmium, barium, titanium, zirconium, tin, lead, and antimony. These elements are used for obtaining specific properties, such as coefficient of expansion, surface texture, color, opacity, acid resistance, etc. The periodic arrangement of the elements serves as a useful guide in regard to porcelain enamel glass chemistry. L.E.T.

Zirconium compounds as opacifiers for glazes. Johannes Löffler. *Ber. Deut. Keram. Ges.*, **19** [6] 228–35 (1938).—After discussing the optical hypotheses for the opacifying effect, L. gives an insight into the silicate chemistry of zirconium oxide in its combinations with soda. Glazes were produced in which the tin oxide was replaced by zirconium oxide as the opacifier, but technical difficulties were encountered; these are enumerated. E.J.V.

Glass

Action of arsenic on the coloring and decolorizing of glass: II. L. Springer. *Glashütte*, **69** [35] 633–34 (1939).—Special studies were made of the action of arsenic on pyrolusite (MnO_2) and iron oxide. The tests are described, and results are given. Pyrolusite with arsenic but without saltpeter gave varying colors, often direct opposites, in an oil furnace. In an electric furnace small or large amounts of arsenic always weakened the color. The addition of saltpeter (in an oil furnace) gave great stability to the coloring, but the arsenic weakened the color tone in proportion to the amount added. In an oil furnace the addition of two parts sulfate to pyrolusite completely destroyed the coloring with small or large additions of arsenic. In an electric furnace sulfate alone did not weaken the color, but with the addition of arsenic the color was weakened. Fundamentally, arsenic acts as a reducer, but if large quantities of arsenic are added to a batch containing selenium compounds and either iron oxide or pyrolusite, the arsenic may also act as reducer in the first stage of fusion. It can also take up oxygen, especially when saltpeter is present (formation of arsenic-five oxide), and in the fining of glass it becomes an oxidizer. Whether this explanation of the oxidizing action of arsenic should be accepted or whether the formation of colorless iron compounds is the cause remains uncertain. For Part I see *Ceram. Abs.*, **19** [4] 88 (1940). M.V.C.

Analysis of selenium in glass. A. E. Pavlish and R. W. Silverthorn. *Jour. Amer. Ceram. Soc.*, **23** [4] 116–18 (1940).

Annealing muffle for hollow glass. Otto Ehinger. *Glashütte*, **69** [50] 822–24 (1939).—E. describes a gas-heated well-insulated muffle in "channel" form for annealing gold borders, markings, and printing, which can be built inexpensively in any plant. Gas firing is economical and can be regulated; it gives more uniform heat, and the charge is not coated. The burner in the furnace is arranged over the muffle. In order to anneal 5000 to 6000 glasses in 8 hr., the muffle (7500 mm. long) is divided into three zones: preheating (2500 mm.), annealing (3000 mm.), and cooling (2000 mm.). The annealing muffle is divided into six parts, each 500 mm. long. The interior width of the channel is 600 mm. M.V.C.

Apparatus for determining chemical attack on glasses. Masao Nagaoka. *Glastech. Ber.*, **17** [12] 327–29 (1939).—The apparatus, of glass construction, is adapted to the powder method of determining solubility. A quartz tube holds the reagent and fits into a compartment which is jacketed and fitted with a boiling flask and condenser to maintain constant temperature. The Pt gauze basket carrying the sample is suspended from an eccentric to furnish adequate stirring. This arrangement permits determination of weight loss, alkalinity, and electrical conductivity. Weight loss seems to be the most suitable measure of chemical attack. A treatment of 48 hr. gives satisfactory results. J.F.H.

Assembling thermocouples. H. M. Trimble. *Ind. Eng. Chem., Anal. Ed.*, **12** [1] 52 (1940).—The use of braided Fiberglas sleeving in the assembling of thermocouples is described in detail. F.G.H.

Colored glass with the changing times. W. Ganzenmüller. *Glashütte*, **69** [45] 761–64; [46] 774–75; [47] 786–88 (1939).—Colored glass has little application today (except for signal glass, luxury articles, etc.) in comparison with colorless transparent glass, but most of the earlier glass was colored. At first there was no choice because impurities, especially the green-coloring iron oxide, were always mixed with the glass. By experimenting with different materials, all colors were eventually obtained: cobalt and copper for blue and copper for green and red (30% copper in some cases, causing verdigris deposit with dampness). The decolorizing action of small amounts of manganese was learned early in Egypt and in Mesopotamia in isolated instances; a single relic dating from 1500 B.C. was found. Colored glass beads, imitation precious stones, and some hollow glass modeled over clay forms were made first. With the discovery of glass blowing, transparent colorless crystal glass became most highly prized (Pliny, Historia Naturalis, XXXVI, 198). The Romans also used colored glass extensively for imitation jewels and mosaic and achieved notable effects with flash glass, the most celebrated example of which is the Portland vase. Colored glass became more popular toward the end of the Roman Empire; perhaps this was the transition period preceding the great joyous expression in colors of the Middle Ages, when, however, the technique and art of glassmaking were no longer of the same high standard and the colors were fewer and less pure. The need of the church for stained-glass windows and magnificent mosaics stimulated the demand for colored glass. The greenish glass for ordinary use, called "forest" glass (*Waldglas*) because its factories were located in the great forests, and some white hollow glass and colorless glass (Venetian glass) were also made in this period. A change in taste is again noted at the beginning of the Renaissance when Venetian and Bohemian colorless glass reached a high degree of perfection in both clarity and form. The baroque period returned to the Gothic preference for colored glass. Bohemian crystal glass reached its highest point in the 17th century, and in the 18th century colorless glass was again out of fashion only to come in again after Napoleon. The gradual development of technique and the introduction of new coloring elements is traced in detail from the early Middle Ages down to the latest innovation, the use of rare earths. A table shows the coloring compounds used from 1400 B.C. to the 17th century. M.V.C.

Discarded materials and waste products as a source of raw materials in the glass industry. Zsch. *Glashütte*, **69** [49] 810 (1939). M.V.C.

Electric strength of fibrous glass. A. Gemmant and F. A. Glassow. *Elec. Eng.*, **58** [8] 341–45 (1939).—The ideal, and probably future, use of fibrous glass for electrical insulation is its use without an organic filler. It is important, therefore, to know its electric strength in an unimpregnated condition. To obtain these data, G. tested four makes of textile glass with both alternating and direct current. The maximum breakdown voltages for alternating current are higher than the corresponding values obtained with direct current. The density of the textile texture has only a slight effect on the electric strength, but further increase of the density should be desirable. The electric strength increases linearly with

pressure (measured up to 5 atm.), although the values are lower than those corresponding to an air gap of the same separation. Measurements up to 350°C. indicate satisfactory electric strength even at higher temperatures, although the puncture values decrease with increasing temperature. Heated, treated, and washed samples, from which the small proportion of oil is removed, prove superior at high temperatures. The leakage resistance (measured up to 160°C.) is satisfactory, decreasing with increasing temperature in the usual manner; oil-free samples again prove superior to the untreated ones. P.G.H.

Etched signs. ANON. *Glashütte*, **70** [2] 18–19 (1940).—The process of etching glass signs for advertising and name placards is described. The construction of the equipment, which includes a washing tank, etching tank, and rinse tank usually of 130-liter capacity, protective coatings for equipment, and safeguards for workmen are dealt with. The etching solution contains 1 part hydrofluoric acid to 3 parts water with additions of sulfuric acid or aqua regia. The washing solution is 10% hydrofluoric acid; hot water containing some soda is used for rinsing. The glass to be etched must first be thoroughly cleaned and dipped in an acid bath and then in cold water before being immersed for 10 to 12 min. in the etching solution and rinsed. For the etching of printing or ornament on plate glass, a protective lacquer is used whose formula is 100 gm. Syrian asphalt, 50 gm. colophony, 20 gm. stearin, and 10 gm. beeswax heated in benzene or oil of turpentine. Another formula is 100 gm. Syrian asphalt and 400 gm. French turpentine mixed with 50 parts stearin, 25 beeswax, and some Burgundy pitch and beef tallow. The lacquer is applied by the pressure method on large lots but separate pieces are painted. Mat etching can be either (1) positive, where the printing and ornament are cut through the lacquer, cleansed with alcohol, and etched, or (2) negative, where they are covered by the lacquer. The inside of the glass plate must be protected unless the etching acid is applied with a brush. M.V.C.

Formation of silver mirrors. J. LOISELEUR. *Compt. Rend.*, **209** [26] 993–94 (1939).—L. made a thorough study of the process of forming a silver mirror on glass in its different stages which showed that such formation rests solely on the action of the charges on the glass wall originating from the reduction of Ag atoms in the liquid ammoniacal silver hydrate. If polyvalent ions, e.g., Al^{+++}, are present, no metallic deposit is possible. M.H.

German glass industry in the age of discoveries. ANON. *Glashütte*, **69** [52] 847–48 (1939).—The 14th and 15th centuries were great periods in the German glass industry. The engraving and painting of glass were highly perfected. M.V.C.

Glass for air-raid precaution purposes. ANON. *Glass*, **17** [1] 11 (1940).—A study made to determine the type of glass most resistant to shattering by bomb explosions, i.e., aerial bombs, indicated that a toughened glass (Armourplate), glass brick, and wired glass were most satisfactory. B.C.R.

Glass of the binary system MgF_2–SiO_2. SHIN-PIAW CHOONG. *Compt. Rend.*, **209** [24] 884–85 (1939).—In general, solutions obtained by dissolving silica in magnesium fluoride solidify as white and opaque enamel, the same as pure MgF_2. Under favorable heating conditions (not clearly defined), however, it is possible to obtain a transparent solution from synthetic MgF_2 and pure fused quartz, as little globules before a flame. The density of these globules is 2.73 to 2.83, in general 2.81 ± 0.01 for the best transparent state. There is no definite fusion point, and the behavior of this substance is similar to that of glass; hence, it can be considered as a new type of glass. A Pt-Pt Rh thermocouple indicated the beginning of fusion at 1460°C., about 60° above the melting point of MgF_2 and 150° lower than that of fused quartz. A red-hot globule of the substance can be plunged in cold water without breaking, while ordinary glass breaks into small fragments under similar conditions. The thermal expansion coefficient of this glass is therefore very small. As the densities of fused quartz and amorphous MgF_2 are 2.20 and 2.47, respectively, a considerable contraction of volume must take place in the formation of this new glass with a density of 2.81; it must be assumed that it contains mainly MgF_2 as its density is closer to that of this substance. The limit of transparency in the ultraviolet region shifts to longer wave lengths with decreasing density. M.H.

Glass brick and lenses. ANON. *Glass*, **16** [12] 460 (1939).—In a study of the ability of specially made glass lenses for use in roofs and pavements to withstand severe, sudden shocks as produced by the ignition of thermite bombs, the results obtained showed that the glass could prevent the passage of incendiary material, even though it shattered due to the intense heat produced. Glass brick may be used advantageously for closing off windows in hospitals and public buildings as a protection against blasts. B.C.R.

Glass defects originate in batch-mixing operation. F. GELSTHARP. *Ceram. Ind.*, **34** [3] 27–28 (1940).—Reactions detrimental to the production of good glass take place in isolated parts of the melt if materials are not properly mixed. General rules in regard to particle size of batch materials are listed; grading tables for glass sand and soda ash are given together with grain sizes for limestone and dolomite. Methods of batch mixing are reviewed; the horizontal drum mixer is most commonly used, and horizontal pan-type mixers are also being used with good results. At some point between the mixer and tank, the batch should be passed over a magnetic separator to remove tramp iron and scale. Opinion is divided regarding mixing cullet with the batch or charging it into the furnace separately; cullet charged to the dog house in random quantities is probably not harmful where only plant cullet is used. More uniformity in melting is maintained by using up each batch separately than by having a large storage tank that is never emptied, as segregation takes place in a large storage tank. Installations of small batch buckets have proved successful. The idea of briquetting the batch has been revived, and many operators consider it the ultimate in batch preparation. Illustrated. L.M.C.

Glasses containing cobalt oxide: II. KITSUZO FUWA. *Jour. Japan. Ceram. Assn.*, **47** [556] 189–91 (1939).—Specific gravity, coefficient of expansion, softening temperature, and electrical resistance were determined for three series of alkali-lime-silica glasses consisting of 72 silica, 12 lime, and 16% alkali, whose content of lime was replaced by 0.01 to 12% of cobalt oxide. The results of the experiment are as follows: (1) The density of each series of the glasses increased with an increase of CoO content. The values for density obtained agreed well with those calculated when the density of the CoO in the glass was assumed to be 6.4 for two series and 8.6 for another. (2) The coefficient of thermal expansion was reduced with an increase of CoO content. Numerical values of the coefficient agreed well with those calculated when 2.4 and 4.0 were used as constants for CoO in two series and the other series, respectively. (3) The softening temperatures were lowered with an increase of CoO. (4) The temperature at which the specific resistance of glass became 1500 ohm/cm. tended to decrease with an increase of CoO. **III.** *Ibid.*, [557] 228–30.—The resistance of the glasses to boiling water, 20.24% hydrochloric acid, a 2 *N* solution of sodium carbonate, and a 2 *N* solution of caustic soda was determined by the powder method with the following results: (*a*) the solubility of alkali in water is increased slightly by the introduction of CoO, showing a maximum when the contents of lime and CoO are equal; (*b*) the solubility in the acid is not affected by the substitution; (*c*) the solubility in the sodium carbonate solution is similar to that in water, but the effect is far less; and (*d*) the solubility in the caustic soda solution is slightly increased by an increase of CoO. S.K.

Glasses containing iron oxide: XV, Density of glass. K. FUWA. *Jour. Japan. Ceram. Assn.*, **46**, 8–11 (1938); *Jour. Soc. Glass Tech.*, **22** [90] 129A (1938).—Using the density factors $SiO_2 = 2.2$, $Al_2O_3 = 2.75$, $CaO = 5$, $Na_2O = 3.47$ (given by S. English and W. E. S. Turner),

and Fe_2O_3 = 4.8 (given by S. English, H. W. Howes, W. E. S. Turner, and F. Winks), the following factors were obtained from the results of analysis of the series of colored glasses already published by F.: K_2O = 2.88, Li_2O = 3.16, and Fe_2O_3 = 4.8; FeO = 7 for soda- and potash-containing glasses; Fe_2O_3 = 6 and FeO = 8 for lithia-containing glasses. Densities calculated by these factors were in good agreement with those obtained by experiment. For Part XIV see *Ceram. Abs.*, **18** [3] 71 (1939).

Glass factories in Erzgebirge and Vogtland, Saxony. ALBERT SCHRÖDER. *Glashütte*, **69** [35] 630–33; [36] 650–53; [37] 666–68 (1939).—The first recorded document mentioning a glass factory in this region was dated 1399, and it is known that twelve or more plants were subsequently established. The histories of the families identified with the most important of these factories are reviewed briefly; the Preussler and the Schürer families were outstanding. Hollow glassware and high-quality crystal glass were made in these factories, but too little is known of the products to permit judging their importance to the history of Saxon or German glass production. It is probable, however, that the factories of this region served as the connecting link of the Bohemian glass factories because of the journeying back and forth of glassmakers of both regions. **Discussion.** HERBERT KÜHNERT. *Glastech. Ber.*, **17** [12] 335–39 (1939). See "History . . .," *Ceram. Abs.*, **19** [2] 43 (1940).
M.V.C. + J.F.H.

Glass fiber in horticulture. A. ROLET. *Nature* [Paris], No. 3056, pp. 151–52 (1939).—Plants and bushes are protected against severe cold or excessive heat by means of glass-fiber jackets. See *Ceram. Abs.*, **18** [11] 293 (1939).
R.W.D.

Glass insulation. ANON. *Elec. Rev.*, **126** [3241] 9 (1940); see *Ceram. Abs.*, **18** [5] 124 (1939). J.L.G.

Glass for optical cells. ANON. *Glass*, **16** [12] 461 (1939).—Fused glass cells for optical work, heretofore made exclusively in Germany, are being manufactured successfully in England. B.C.R.

Glass in television. BRUNO SCHWEIG. *Glass*, **17** [1] 8 (1940).—The extent to which glass is utilized in the construction of television equipment is discussed in detail.
B.C.R.

Grain size of glass raw materials. ANON. *Glashütte*, **69** [49] 809–10 (1939).—Ground or powdered raw materials for the production of glass for laboratory tests should not be stored long before use because physical changes as well as chemical changes (weathering) take place in the silos. The physical state, i.e., the grain size, of raw materials has been found to affect the chemical reactions in the batch. The case of lime for a sheet-glass tank is cited: when finely ground lime, which is easily decomposed, was used, streaks and knots were formed in the melt by the remaining unfused matter. This defect was eliminated when a coarser grain size (2.0 mm.) for lime was used. A sieve analysis of lime stored 5 to 40 days showed that the lime gradually crumbled into finer particles with lengthened storage time. M.V.C.

Ground glass windows. RICHARD SÜSSMUTH. *Glashütte*, **68** [47] 809–11 (1938).—Where a decorative colorless glass is desired for windows and translucent but not transparent walls, ground glass can be used. Geometrical figures, grooves, animal and human figures, and pictorial designs in relief break up the light and animate the window surface. Crystal plate glass and fusible glass, tinted or untinted, are easy to grind. Decorative windows of ground glass are illustrated. M.V.C.

Improved method of mirror production. PEACOCK LABORATORIES, INC. *Ind. Eng. Chem., News Ed.*, **14** [13] 272–73 (1936).—Improvements in the technique of silvering are described. Illustrated. F.G.H.

Influence of silica on the gas content of glass melts (displacement of SO_3 by SiO_2). H. JEBSEN-MARWEDEL. *Glastech. Ber.*, **17** [12] 325–27 (1939).—Analysis of a series of soda-lime-silica glasses with 2% of the Na_2O introduced as sulfate shows that, with increasing SiO_2 content, there is a proportionate drop in SO_3 content. This displacement of SO_3 as solution of SiO_2 progresses is an important factor in gas evolution and fining. J.F.H.

Innovations in the use of glass. HEINRICH FUCHS. *Glashütte*, **70** [1] 5–7 (1940).—Decorative and serviceable table lamps are shown in which the base as well as the shade is made entirely of glass, and the light source is constructed in a way best suited to the special characteristics of glass. M.V.C.

Manufacturing processes of plate glass. C. C. *Glaces & Verres*, No. 61, pp. 7–13 (1939).—A short description of the Bicheroux method and of the continuous rolling process is given. R.W.D.

Measurement of gas temperatures in glass furnaces. M. PARKIN. *Jour. Inst. Fuel*, **12** [64] S61–64 (1939).—P. describes a series of experiments on temperature determination in the regenerator system of a glass furnace. A comparison is drawn between bare thermocouples of platinum and of base metals, a simple suction pyrometer, and a heated junction thermocouple of the Schmidt type. Bare platinum couples are most satisactory for the purpose.
H.E.S.

Melting currents in glass tanks. ANON. *Ceram. Ind.*, **34** [3] 40–43 (1940).—The best method of studying currents in glassmelting tanks seems to be the testing of commercial tanks in production. Tests that have been made are described. Results show that glass flows radially from all directions into the throat and emerges as a surface current in the working end with a continuous diminution of its depth of flow. At least two types of currents are present in any except a pot furnace: (1) straight or longitudinal currents, since fresh streams of metal are constantly flowing from the melting to the working end; and (2) transverse convection currents, due to the existence of temperature gradients and local differences of density in the molten bath. Fluxes soon melt and settle to the bottom, leaving the more refractory constituents on top; transverse currents, therefore, do much to enhance homogeneity. The result of the two types of currents is a horizontal spiral progressing from batch to working end, causing the melted glass to reach the working end at a greater rate than it is being removed and setting up a counter-current back to the melter. Tank design influences speed and direction of currents; currents in a tank of conventional design are described. The design and depth of the basin, amount of narrowing in the cooling zone, the presence of floaters, and the arrangement of ports are of prime importance in controlling tank currents. A discussion is included. Illustrated. L.M.C.

Melting glasses of different compositions in a pot furnace. K. V. MANZHURNET AND V. E. SEMENOV. *Stekolnaya Prom.*, **15** [7] 14 (1939).—Four kinds of glass for tubes and rods were melted simultaneously in a 12-pot furnace fired with unpurified gas. M.V.C.

Optical constants of glasses. HANS SCHULZ. *Glashütte*, **69** [35] 620–30; [36] 653–55 (1939).—The optical constants of glasses are better for characterizing their type than other values such as the mechanical properties (tensile strength, resistance to pressure, density, etc.), because they can be determined with greater accuracy by simple means and permit certain conclusions to be drawn regarding the composition of the glass. The problem of the relationship between the optical constants and the composition of glass is dealt with in detail, and the work of other investigators is summarized. A table gives values for the optical constants n_0 (index of refraction), c, and λ_0 (wave length) for glasses of the new Schott catalogue No. 5858, computed according to the Hartmann formula, $n = n_0 + \frac{c}{\lambda - \lambda_0}$. The work of E. Zschimmer, F. E. Wright, H. Mees, H. Karmaus, and others, experiments on the effect of increasing additions of certain constituents in the glass (PbO), a comparison of calculated and measured values for the index of refraction, and the effect of the infrared and ultraviolet absorption fields are discussed. A simple relationship between optical constants and composition may be found only after more exact values of a greater number of glasses of known composition can be

determined in one larger wave-length interval; the measurements so far obtained are insufficient. M.V.C.

Optical glasses. L. POICHET. *Nature* [Paris], No. 3049, pp. 313–14 (1939).—P. deals with the question of cambered glasses, or "periscopic" glasses as Wollaston termed these corrective glasses in a paper published in *Phil. Mag.* in 1803. R.W.D.

Preventing the solution of silicic acid during the storage of natural water in glass containers. B. A. SKOPINTSEV AND E. I. PLETNIKOVA. *Zhur. Priklad. Khim.*, **10**, 1310–13 (1937); *Chem. Abs.*, **32**, 1822 (1938).

Progress in the manufacture of silvered-glass reflectors. WILLIAM IRBY. *Gen. Elec. Rev.*, **43** [2] 89–90 (1940).—Improvements in the manufacture of silvered glass for floodlight reflectors and various tests for determining its life in service are discussed. Silvered-glass reflectors are more suitable than metal reflectors, because they offer the highest reflectivity of any practical reflector obtainable. The ability of the protective backing to withstand extremes in temperature, high humidity, etc., is important. The recently developed porcelain enamel backing has finally solved the problem. The silvering is virtually sealed in between two layers of glass and offers the greatest long-life efficiency. Illustrated. L.E.T.

Propane and acetylene in lamp-working shops. THEO ZIENER. *Glastech. Ber.*, **17** [12] 329–35 (1939). J.F.H.

Quartz glass and quartz ware, exceptional industrial materials. ANON. *Glashütte*, **69** [30] 514–15 (1939).—The low expansion coefficient, high electrical insulating capacity, high resistance to mineral acids (except hydrofluoric acid and concentrated phosphoric acid at temperatures over 300°), and permeability to ultraviolet rays of quartz ware offset the expense of its manufacture. It is used for utensils and apparatus for wholesale chemical industries, for quartz lamps, decorative articles, etc. See *Ceram. Abs.*, **14** [9] 215 (1935). M.V.C.

Revolutionary process of mirror manufacture. ANON. *Ind. Eng. Chem., News Ed.*, **18** [5] 199–200 (1940).—A brief description is given of the development of a process and the commercial equipment by which a pure silver-reflecting film can be produced by spraying a solution of silver nitrate on glass. Illustrated. See "Mirror . . .," *Ceram. Abs.*, **18** [6] 152 (1939). F.G.H.

Significance of the mineralogical composition of quartz sand when melting glass. M. A. BEZBORODOV, A. S. ZAPOROZHTSEVA, AND I. G. MOISEEVA. *Stekolnaya Prom.*, **15** [7] 26–29 (1939).—When evaluating quartz sands it is necessary to know not only their chemical and granulometric composition but also the mineralogical composition. Because of the difficulty of dissolving separate minerals, particularly zircon and kyanite, it is very important to observe the melting of the glass so that incompletely melted components will not penetrate into the working zone and be dissolved later by the glass mass. Besides the minerals mentioned, experience shows the difficult assimilation of small lumps of kaolin. Iron inclusions introduced into the melt in one way or another are also difficult to digest. A polarization microscope is necessary for a thorough study of stones present in glass and their mineralogical composition. See "Solubility . . .," *Ceram. Abs.*, **18** [11] 294 (1939). M.V.C.

Sodium fluosilicate in the glass batch. ZSCH. *Glashütte*, **69** [47] 785–86 (1939).—Sodium fluosilicate is excellent for fining brown glass colored with sulfide, green glass fused with sulfate, certain colored glasses fused without sulfate or saltpeter, white hollow glass, and certain tube glasses which must not contain arsenic. Sodium fluosilicate is a salt obtained in the preparation of superphosphate; it is relatively pure and free from iron and does not vary in composition. Because of its high fluorine content, it is a more effective fining agent than fluorspar, and its decomposition into the volatile silicon tetrafluoride (the fining agent in the batch) and sodium fluoride (which is destroyed at higher temperatures and does not cause opacification) takes place at lower temperatures than that of fluorspar. The decolorizing action of the fluorides is caused by the formation of iron fluoride which is volatile at fusion temperatures (1000°) and also by the formation of the colorless complex and double salts. The amount of silicic acid which volatilizes lies within the weight error for the batch. Sodium fluosilicate cannot be used in place of borax. M.V.C.

Spherical ground joints for vacuum systems. S. M. RUBENS AND J. E. HENDERSON. *Rev. Sci. Instruments*, **10** [2] 49–50 (1939).—Stopcocks having as many connection combinations as desired are described, and their use in spherical ground glass joints is illustrated. The rough surface and shape is first formed by blowing the glass parts in a heated carbon mold. Further shaping of the joint is accomplished by grinding with steel tools with the aid of progressively finer abrasive powders. H.E.S.

Stresses in bottles or jars from differences in outside and inside temperatures (static temperature gradient). F. W. PRESTON. *Jour. Amer. Ceram. Soc.*, **23** [4] 119–21 (1940).

Structure of broken surfaces and the breaking process in glasses. Reply to the remarks of A. Smekal. ERNST REXER. *Glastech. Ber.*, **17** [12] 339 (1939); see *Ceram. Abs.*, **19** [1] 10 (1940); "Shattering . . .," *ibid.*, **18** [7] 179 (1939). J.F.H.

Use of sandstone with a high alumina content in the production of pane glass by the Fourcault method. YU. TS. VINOGRADOV AND S. V. RODIN. *Stekolnaya Prom.*, **15** [7] 8–13 (1939).—The composition of sandstone and problems confronting its use for glass manufactured according to the Fourcault method are dealt with. M.V.C.

Vitreous state and the transformation point of glasses. E. JENCKEL. *Z. Elektrochem.*, **45**, 202–14 (1939); *Science Abs.-A*, **42** [496] 384 (1939).—J. discusses the subject of the vitreous state thoroughly under the following headings: transition from melt to glass, nature of the internal equilibrium and the velocity of its production, and structure of glass. See "Character . . .," *Ceram. Abs.*, **17** [10] 325 (1938). H.K.R.

Water-spray curtain as a protection to health in the glass industry. FRITZ PRASSE. *Glashütte*, **68** [42] 732–33 (1938).—Many methods have been tried to reduce temperatures near the furnace for the protection of workers. The water-spray curtain solves the problem satisfactorily. Water under 4- to 6-atm. pressure is forced through a patented nozzle with stepwise perforations; it produces a conical spray in the shape of a comet's tail which acts as a protecting wall against the heat radiations, cools the air, and also settles dust. The complete installation of this apparatus is described; it is adjustable to all measurements and can be swung out of the way. The nozzles can be set in any direction to suit all requirements, and the parts are of rustproof brass and can be replaced. M.V.C.

PATENTS

Agricultural application of glass wool. GAMES SLAYTER AND J. H. THOMAS (Owens-Corning Fiberglas Corp.). U. S. 2,192,939, March 12, 1940 (May 17, 1937).

Apparatus for making hollow glass blocks. H. H. BLAU (Corning Glass Works). U. S. 2,191,953, Feb. 27, 1940 (Oct. 12, 1937).

Apparatus for the manufacture of mineral wool. E. R. POWELL (Johns-Manville Corp.). U. S. 2,192,524, March 5, 1940 (July 20, 1935).

Apparatus for manufacturing glass wool. J. H. THOMAS (Owens-Corning Fiberglas Corp.). U. S. 2,192,944, March 12, 1940 (May 11, 1937).

Building block assembly apparatus. M. K. HOLMES AND DAVID JONES (Owens-Illinois Glass Co.). Can. 386,357, Jan. 16, 1940 (Sept. 10, 1937; in U. S. April 19, 1937). G.M.H.

Conductor with spun-glass core. E. S. MCCONNELL (Anaconda Wire & Cable Co.). U. S. 2,193,429, March 12, 1940 (Jan. 6, 1937).

Container for molten glass. P. G. WILLETTS (Hartford-Empire Co.). Can. 386,049, Jan. 2, 1940 (Oct. 13, 1938). G.M.H.

Forming sealed hollow articles of glass. H. H. BLAU (Corning Glass Works). U. S. 2,191,951, Feb. 27, 1940 (Sept. 8, 1937).

Glass article forming machine. L. D. SOUBIER (Owens-Illinois Glass Co.). Can. 386,184, Jan. 9, 1940 (Sept. 3, 1937; in U. S. April 5, 1937). G.M.H.

Glass block forming apparatus. R. H. BARNARD. Can. 385,798, Dec. 26, 1939 (Sept. 18, 1939). G.M.H.

Glass block reinforcement. C. H. SPECHT. Can. 385,714, Dec. 19, 1939 (Sept. 15, 1938). G.M.H.

Glass block section joining apparatus. L. D. SOUBIER (Owens-Illinois Glass Co.). Can. 386,067, Jan. 2, 1940 (June 24, 1937; in U. S. July 2, 1936). G.M.H.

Glass body perforating apparatus. C. E. HAHN AND P. P. SHEBEL (Canadian General Electric Co., Ltd.). Can. 386,311, Jan. 16, 1940 (Jan. 13, 1937). G.M.H.

Glass chilling and tempering apparatus. LAMBERT VON REIS (Soc. Anon. des Manufactures des Glaces & Produits Chimiques de St. Gobain, Chauny & Cirey). Can. 386,202, Jan. 9, 1940 (Dec. 9, 1937). G.M.H.

Glass-cutting machine. G. W. BURROUGHS. U. S. 2,190,641, Feb. 20, 1940 (Oct. 5, 1937).

Glass-handling apparatus. EARL HIATT AND J. J. MACKEN (Owens-Illinois Glass Co.). U. S. 2,191,143, Feb. 20, 1940 (Feb. 3, 1939).

Glass machine. J. W. ERRETT (Capstan Glass Co.). U. S. 2,192,302, March 5, 1940 (July 8, 1935).

Glassmelting furnace. P. G. WILLETTS (Hartford-Empire Co.). Can. 386,048, Jan. 2, 1940 (Oct. 13, 1938; in U. S. Nov. 4, 1937). G.M.H.

Glass-to-metal seal. F. H. A. BRANDT. U. S. 2,192,892, March 12, 1940 (April 6, 1937). LOUIS NAVIAS (General Electric Co.). U. S. 2,193,640, March 12, 1940 (May 21, 1938).

Glassware-forming apparatus. A. E. BROWN (Owens-Illinois Glass Co.). Can. 386,069, Jan. 2, 1940 (Sept. 10, 1937; in U. S. April 16, 1937). G.M.H.

Glassware-forming machine. FRANK O'NEILL (Owens-Illinois Glass Co.). U. S. 2,191,132, Feb. 20, 1940 (March 16, 1936).

Hardening or tempering glass plates and articles. B. STRAUSS. Brit. 518,106, Feb. 28, 1940 (Sept. 18, 1937).

Heat-insulating glass. EDWARD DANNER. U. S. 2,193,393, March 12, 1940 (Aug. 17, 1936; Oct. 5, 1937).

Heat insulation. A. D. SABORSKY (Owens-Corning Fiberglas Corp.). U. S. 2,192,933, March 12, 1940 (June 30, 1937).

Hollow cylindrical bodies made from glass or other fibers bound by adhesive. GLASS FIBRES, LTD., AND D. MCCANN. Brit. 518,147, Feb. 28, 1940 (Sept. 20, 1938).

Hollow glass article producing apparatus. L. D. SOUBIER (Owens-Illinois Glass Co.). Can. 386,068, Jan. 2, 1940 (July 23, 1937; in U. S. Feb. 1, 1937). G.M.H.

Laminated product. W. H. CAROTHERS (E. I. du Pont de Nemours & Co.). U. S. 2,191,367, Feb. 20, 1940 (Feb. 15, 1937).

Laminated safety glass. C. J. MALM (Eastman Kodak Co.). U. S. 2,192,196, March 5, 1940 (May 16, 1936, renewed May 2, 1939).

Lehr stacker for glassware. ORIE SHACKELFORD. U. S. 2,191,591, Feb. 27, 1940 (March 16, 1937).

Lens. G. H. AKLIN AND F. E. ALTMAN (Canadian Kodak Co., Ltd.). Can. 385,870, Dec. 26, 1939 (May 12, 1938; in U. S. April 16, 1938). G.M.H.

Lens grinding and polishing machine. W. A. LOCKHART (Shuron Optical Co., Inc.). U. S. 2,192,486, March 5, 1940 (Sept. 1, 1937).

Machine for the manufacture of glass articles. T. F. PEARSON (Crown Cork & Seal Co., Inc.). U. S. 2,191,237, Feb. 20, 1940 (Sept. 15, 1936). U. S. 2,193,376, March 12, 1940 (June 17, 1937).

Making glass-to-metal seals. STANTON UMBREIT (Radio Corp. of America). U. S. 2,189,970, Feb. 13, 1940 (Oct. 30, 1937).

Making hollow glass building blocks. H. H. BLAU (Corning Glass Works). U. S. 2,191,952, Feb. 27, 1940 (Sept. 16, 1937).

Manufacture of ceramic liquid containers and molds therefor. S. ARCARI AND S. ARCARI. Brit. 517,204, Feb. 7, 1940 (July 22, 1938).

Method and apparatus for delivering and gathering glass. A. F. TREMBLAY (Kent-Owens Machine Co.). U. S. 2,191,733, Feb. 27, 1940 (Jan. 13, 1936).

Preparing cellular materials. E. H. HAUX (Pittsburgh Plate Glass Co.). U. S. 2,191,658, Feb. 27, 1940 (Jan. 22, 1938).

Using grinding glass sands. J. R. JONES (Blue Ridge Glass Corp.). U. S. 2,191,962, Feb. 27, 1940 (March 28, 1938).—The process comprises removing iron particles from the slurry of glass-grinding machines, separating the sand remaining in the slurry according to particle size, and feeding the separated sand to glass-grinding heads.

Structural Clay Products

Manufacture of structural clay products. F. E. EMERY. *Civil Eng.*, **7**, 755–59 (1937); *Chem. Abs.*, **32**, 741 (1938).

PATENTS

Building brick. J. W. MUTCH (Edward W. DeWilton). U. S. 2,192,691, March 5, 1940 (Nov. 4, 1938).

Hollow building block. L. S. FOWLER. Can. 385,693, Dec. 19, 1939 (June 10, 1938). G.M.H.

Insulating block. D. D. WHITACRE. U. S. 2,192,723, March 5, 1940 (July 11, 1936).

Interlocking building block. P. W. GROTH. U. S. 2,192,970, March 12, 1940 (July 22, 1938).

Manufacture of brick, etc. B. PRIESTLEY, F. CREIGHTON, AND W. CREIGHTON. Brit. 517,305, Feb. 7, 1940 (July 23, 1938).

Method and apparatus for making brick. G. W. DENISON AND L. A. DENISON. U. S. 2,191,106, Feb. 20, 1940 (Feb. 10, 1937).

Waterproof brick wall. J. A. POROMA. U. S. 2,192,366, March 5, 1940 (Sept. 8, 1936; Oct. 4, 1938).

Refractories

Aluminous cement as a bond for refractory concretes. A. V. HUSSEY. *Chem. & Ind.*, **56** [3] 53–61 (1937).—On heating concrete containing grog (crushed firebrick) and aluminous cement, the first stages of dehydration (<100°) cause a loss of strength, which is partly regained up to 200°. Further dehydration causes loss of strength (300°); oxidation of the Fe produces an increase of strength up to 700°. From 700° to 1000° strength falls only a little below the 100° value but rises as a ceramic bond is formed from 1000° to 1250°. This last gain is greater for leaner concrete. Above this temperature, vitrification occurs. On heating under load (25 lb. per sq. in.), the yield point is about 1300°, and higher temperatures can be used with more refractory aggregates. Concrete which has been heated to this region rehydrates with H_2O when cold and regains a portion of its original strength. The thermal expansion is the same as that for firebrick, and rapid temperature changes (even quenching from 1200°) do not cause spalling. The thermal conductivity is about 0.0026 Cal./sq. cm./sec./°C./cm., and the material can be used exactly as ordinary aluminous cement concrete, needing attention only to the rapid setting and high H_2O requirements. Work can be taken to its normal working temperature 24 hr. after mixing.

Bi-ceramics. MERLIN. *Kachestvennaya Stal*, **1935**, No. 8, pp. 51–53; abstracted in *Chem. Zentr.*, **1936**, I,

4346.—Data are given on the manufacture of products which consist of layers of at least two refractory materials, such as magnesite, silica, grog, etc. M.V.C.

Brick from dead-burned magnesite with the addition of raw magnesite. G. M. TAZITDINOV. *Ogneupory*, **7** [1] 23–24 (1939).—Raw magnesite added to dead-burned magnesite dissociates during the firing of the brick without cracking it. The properties of the fired brick change as follows: (*a*) specific gravity does not change; (*b*) volume weight and mechanical strength decrease; (*c*) porosity and water absorption increase; (*d*) deformation under load at high temperature remains unchanged; and (*e*) thermal stability does not change in spite of increased porosity. M.V.C.

Calculation of grog and semiacid mixes. I. SH. SHVARTSMAN. *Ogneupory*, **6** [12] 1691–98 (1938).—Two methods of computing grog and semiacid mixes are given. 2 nomographs. M.V.C.

Change of structure and mineralogical composition of serpentines and dunites on firing. A. V. RUDNEVA. *Ogneupory*, **7** [1] 54–61 (1939).—The results of petrographic studies on the thermal treatment of talc and serpentinites from the Urals are discussed. The determination of the mineral phases of dunites which underwent thermal treatment is dealt with. The comparative analysis of the fired products of talc, serpentinite, and dunite obtained at high temperatures shows that dunite refractories are superior in refractoriness to the other products. Dunite refractories no longer contain metasilicates at 1500°, and they consist chiefly of forsterite crystals, a highly refractory material which may be used extensively as a basic or neutral refractory. M.V.C.

Chemical analysis of refractories and their raw materials. SHOICHIRO NAGAI AND KEI-ICHI AKIYAMA. *Jour. Japan. Ceram. Assn.*, **47** [556] Supp. 1–4 (1939). S.K.

Comparison of slag wool and other industrial insulating materials: II, Results of experiments on several insulators by a cylinder process. YOSHIAKI TADOKORO AND NITARO ODA. *Jour. Japan. Ceram. Assn.*, **47** [556] 179–88 (1939).—The thermal conductivities of insulating brick made of 10% clay and 90% diatomaceous earth and sawdust and the conductivities of five insulators used for marine steam pipes were determined by a cylinder process. The conductivities at 100°C. were as follows:

New compound insulator	4.63×10^{-4}
New compound insulator	4.97×10^{-4}
Old insulator	5.80×10^{-4}
Paint	6.10×10^{-4}
Asbestos insulator	18.02×10^{-4}
Insulating brick	9.50×10^{-4}

Each test piece was a thick tube 5.4 cm. wide in inside diameter. It was laid horizontally, and a Nichrome heater 5 cm. thick and 31 cm. long was inserted into it. Six or seven small holes were bored in a row on the tube for base-metal thermocouples. Thermal conductivity was calculated by the equation $K = \frac{0.239 \times e \times i \times \log_e r_2/r_1}{L \times 2\pi (t_1 - t_2)}$, where e = volts, i = amperes, r_1 and r_2 = distances from the center to the surface of the heat source and of the insulator, respectively, t_1 and t_2 = temperatures at r_1 and r_2, respectively, and L = length of the insulator. The relations between (1) time and temperature at each depth, (2) depth and temperature, (3) watts and temperature, (4) temperature and conductivity, and (5) thickness of the tubes and loss in cal. per cm. per sec. are shown by diagrams. S.K.

Composite chrome refractories: Summary. W. J. REES AND T. R. LYNAM. *Iron & Steel Inst., Special Rep.*, No. 26, pp. 167–74 (1939).—Initial experiments on high-temperature mechanical strength, shrinkage, porosity and permeability, spalling resistance, and slag resistance of chrome-silica mixtures are briefly reviewed. From later service tests it appears that the disadvantage of decreased slag resistance is of more consequence, when chrome-silica brick are subjected to the severe conditions of open-hearth steel furnaces, than their enhanced resistance to high-temperature deformation; chrome-silica brick proved less durable in the back wall and gas slopes than ordinary chrome refractories, but under less severe conditions in soaking pits, useful service was obtained. Similar initial experiments on chrome-calcined Indian bauxite mixtures are briefly reviewed. From disappointing service tests it was concluded that although the complex iron oxide-magnesia-alumina bond of the brick is viscous enough to give satisfactory refractoriness under load when tested by the normal rising-temperature method, the time factor operates adversely in service, the bond slowly flowing and allowing the brick to deform. This deficiency, a direct result of the absence of reaction and intercrystallization between the two major components of the brick, cannot be effectively overcome without considerable modification in the raw batch composition. Preliminary laboratory work on composite chrome-magnesite mixtures is briefly reviewed, followed by a review of the production of chrome-magnesite brick under works conditions. The importance of particle-size grading of the raw batch is discussed. Under normal industrial firing conditions a noncontinuous crystalline bond of forsterite results. The possibility of developing a continuous bond of forsterite was studied. An addition of 10% talc concentrate to a 75:25 chrome-magnesite mix, followed by high-temperature (1560°C.) firing, led to increased high-temperature strength due to a more continuous crystalline forsterite bond. Similar chrome-magnesite brick have been of considerable benefit to the industry, and present work is being concentrated on the effect of open-hearth service conditions on them, particularly on the disruptive absorption of iron oxide by the brick. Experiments with lime-bonded, barium sulfate-bonded, and barium carbonate-bonded chrome brick are briefly reviewed. P.S.D.

Crucibles for high-frequency steel-melting furnaces. A. T. ZHAK AND B. V. IVANOV. *Ogneupory*, **7** [2–3] 157–64 (1939).—The life of crucibles for high-frequency steel-melting furnaces is dealt with. The problem of increasing the stability of linings of crucibles can be solved only by extensive studies. Several refractory linings are analyzed: (1) a mix of melted magnesite with a bond of lime milk, (2) a mix of melted magnesite with a bond of wet ground melted magnesite, (3) a mix used in Sweden composed of MgO, and (4) a dolomite mix used in England. M.V.C.

Developments in open-hearth furnaces: III, Insulation of open-hearth furnaces. L. F. REINARTZ. *Ind. Heating*, **3** [8] 515–16, 518 (1936).—R. points out the economic advantages of insulating the open-hearth furnace.

Effect of addition of alumina on the fundamental properties of magnesite brick. G. M. TAZITDINOV. *Ogneupory*, **7** [1] 24–27 (1939).—The effect of various admixtures on the properties of magnesite brick was studied. The results of the addition of alumina in the form of corundum to a magnesite brick mix are as follows: (1) volume shrinkage, mechanical strength, and volume weight decrease with increased corundum content, while porosity and water absorption increase; and (2) thermal stability increases with an addition of corundum up to 10% and later decreases, and the temperature of softening decreases. M.V.C.

Effect of the thermal stability of steel-casting molds on the pollution of steel by sand. S. T. ZAĬKOV. *Ogneupory*, **7** [1] 39–41 (1939).—Z. found that refractory molds used for casting steel products have a higher thermal stability when fired at 950° to 980° than when fired at 1100°. M.V.C.

Electric furnace with rods of the Globar type for determining the thermal resistance of refractories at 1300°. M. N. BLUVSHTEIN AND B. N. VOEVODIN. *Ogneupory*, **7** [1] 42–49 (1939).—Silicon carbide rods are used for heating. M.V.C.

Experiments on the use of refractory concretes based on aluminous cement. A. I. ROĬZEN. *Ogneupory*, **6** [9] 1442–48 (1938).—Unfired refractory and slag-resistant concrete whose composition is 6.6 SiO_2, 2.9 Fe_2O_3, 46.1

Al_2O_3, 42.7 CaO, and 0.61% MgO and which has a refractoriness of 1410° can be used in the refractory industry. Concrete with a grog filler (kaolin grog) can be used for saggers and for lining cars in tunnel kilns. M.V.C.

Formation of graphite and its properties. N. P. Bozhko. *Zhur. Priklad. Khim.*, **9**, 1038–48 (1936); *Chem. Abs.*, **31**, 2520 (1937).—Coke yields a hard, and anthracite a soft and oily, graphite with the swelling in a perpendicular direction to the layers of anthracite. The difference between graphite formed from anthracites and that from cokes is given by the orientation of crystals of graphite in the layers of anthracite, where the surfaces (002) of graphite arrange themselves parallel to the layers. Sharp changes in the structure of anthracite occur at temperatures of 2000° to 2300°; these are caused by evaporation of the ash ingredients from anthracite. The orientation of the crystals of graphite in the layer of anthracite is clearly shown at the above temperature interval. The experiment was carried out in the Tammann furnace. Three types of coke and anthracite were used: petroleum, tar, and foundry coke, anthracite from the Nesvet'ev vein, anthracite "Kulak," and anthracite No. 1. Experimental details and photomicrographs of graphites are appended. 13 references.

Heat-insulating materials: I. Toshio Nakai and Yoshio Fukami. *Jour. Japan. Ceram. Assn.*, **47** [558] 283–87 (1939).—The plate method of determining thermal conductivity has been introduced by Shiro Nukiyama. The determinations were made on a glass wool, a diatomaceous earth, and a diatomaceous-earth brick. The relation between conductivity and bulk density is shown by diagrams and is discussed. X-ray diffraction and true specific gravity of the insulating brick were determined, and it was verified that a change in the lattice structure of the material has considerable effect on the thermal conductivity of the brick. S.K.

Heat insulation. Anon. *Métallurgie*, **72** [1] 9–11 (1940).—A review is given. J.M.N.

Heat insulation in the gas industry. M. Y. Mayor. *Jour. Usines Gaz*, **63** [7] 151–54 (1939).—Practical considerations on the subject are given. R.W.D.

Heat insulation for modern American steam power plants. E. T. Cope. *Jour. Inst. Fuel*, **13** [69] 44–49 (1939).—Standardization of test methods and specifications for thermal insulation are now under way. The acceptance of uniform test methods will facilitate comparison of the physical properties of competitive products. H.E.S.

Improved magnesite crucible. Welton J. Crook, John R. Cunningham, and James R. Cady. *Ind. Eng. Chem., Anal. Ed.*, **12** [1] 48–51 (1940).—A new method of producing magnesite crucibles for laboratory purposes is proposed. The base material is crushed magnesite brick which is sintered at 2000°C. in a graphite mold placed in a high-frequency furnace. Crucibles made in this manner are impervious to liquid basic slags which not only permeate but actually disintegrate commercially available magnesia and magnesite crucibles. Illustrated. F.G.H.

Increasing the life of blast-furnace linings. V. Rybnikov. *Stal*, **1936**, No. 11, pp. 95–99; *Jour. Iron & Steel Inst.*, **137** [1] 171A (1938).—R. describes experiences with chamotte brick pressed pneumatically at pressures up to 600 kgm. per sq. cm. Such brick had a porosity of 10 to 15% and a specific gravity of 2 to 2.1, were resistant to temperatures up to about 1700°C., and withstood, without destruction, 100 to 435 thermal cycles as compared with a resistance shown by ordinary chamotte brick to 12 to 25 cycles.

Influence of fluxes on melting and softening temperatures of silicoaluminous fire-clay products. M. Lépingle. *Ind. Chim. Belge*, **10** [7] 267–76 (1939).—L. refers particularly to the production of refractory materials (cements) used either as protective coatings or for hot furnace repairs. R.W.D.

Introduction to investigations on steelworks refractories. T. Swinden. *Iron & Steel Inst., Special Rept.*, No. 26, pp. 17–20 (1939).—The complete work program of the British Refractories Research Assn. is outlined and discussed briefly. P.S.D.

Irreversible sagging of refractories at the softening point under load. P. Bremond. *Arts du Feu*, **2** [9] 90–91 (1939).—Tests show that this initial phenomenon is general. It is due not to elasticity but to the contraction of pores or modifications in the aggregation of solid parts. F.E.V.

Krasnodar serpentinites as raw materials in the manufacture of forsterite refractories. V. M. Tsynkina. *Ogneupory*, **6** [12] 1682–90 (1938).—Tests show that serpentinites from Krasnodar are excellent raw materials for forsterite refractories. The density and the mechanical strength of forsterite refractories were greatly increased by a preliminary fine grinding and briquetting of the raw material with magnesite. See "Olivine . . .," *Ceram. Abs.*, **18** [5] 129 (1939). M.V.C.

Life of refractories in open-hearth furnaces. E. P. Kobylyanskiĭ. *Ogneupory*, **7** [1] 36–39 (1939).—The behavior of silica brick in the crowns of open-hearth furnaces of southern Russia metallurgical mills was studied. The life of the refractories depends on the melting conditions prevailing in the furnaces. M.V.C.

Magnesia spinel. Shin-ichi Suzuki. *Jour. Japan. Ceram. Assn.*, **47** [558] 302–309 (1939).—S. studied the refractoriness, load-bearing behavior, solubility in normal solutions of mineral acids, linear expansion, and microstructure of magnesio-aluminous bodies made of Manchurian magnesites, alumina, and inland diaspores. Results are as follows: (1) the spinel bodies are sufficiently matured at cone 18; and (2) the formation of the spinel is favored by an introduction of boric and silicic acids. S.K.

Manufacture of forsterite refractories: I. Toshio Ikeda and Tsutau Furukawa. *Jour. Japan. Ceram. Assn.*, **47** [558] 287–92 (1939).—A light-burned magnesite from Daisekkyo and a calcined talc from Kaijo were mixed. Small plates were formed under a pressure of 500 kgm. per sq. cm. and fired at 1250°, 1350°, and 1450°C. for 2 hr. They were then examined for shrinkage, absorption, bulk density, specific gravity, and compressive strength. $2MgO \cdot SiO_2$ produced forsterite easily at lower temperatures. X-ray observation showed that fired talc consisted of clinoenstatite and silica; $2MgO \cdot SiO_2$ fired at 1250° contained clinoenstatite, but when fired at 1450° it was composed almost entirely of forsterite. S.K.

Manufacture of high-grade firebrick of highly aluminous clays (preparatory report). Kozo Kawai and Shuzo Shiowaki. *Jour. Japan. Ceram. Assn.*, **47** [555] 136–40 (1939).—In Japan, most highly aluminous brick are made from fire clays of Manchuria and North China. Their P.C.E. reaches cone 37 or 38. They are not satisfactory because their softening temperature under a load of 2 kgm. per sq. cm. never exceeds 1400°C. To obtain firebrick which contain corundum and mullite but no free silica, alumina or diaspore and mineralizers were added to highly aluminous Chinese clays, and the brick were fired to cone 18 and higher. The products were examined for physical properties, X-ray diffraction, and microstructure. They showed a true specific gravity of 3.09 and 3.10, an absorption of 9.72% and 8.33%, and a softening temperature under a load of 2 kgm. per sq. cm. of 1535° and 1555°C. S.K.

Methods of manufacturing alumina from highly aluminous materials of Korea, Manchuria, and North China. Shoichiro Nagai. *Jour. Japan. Ceram. Assn.*, **47** [559] Supp. 37–48 (1939).—Various methods (mostly patented by N.) of extracting alumina from highly aluminous materials produced in Korea, Manchuria, and North China are discussed. Highly aluminous clays of these countries consist of kaolinite and diaspore. A linear relation exists between their content of alumina and their specific gravity. Alumina can be extracted almost completely from materials which consist mostly of diaspore by treating them with a caustic alkali solution in an autoclave. Clays containing over 60% of alumina are melted with lime in an electric furnace into a melt rich in tri-

calcium aluminate. The melt is then treated with a mixed solution of alkali carbonate and caustic alkali. The same clays and those less rich in alumina are fired together with soda ash and limestone in a rotary kiln. A yield of about 95% alumina can be obtained by treating the powdered product with water and a dilute alkali solution. Korean nepheline is favorably treated with concentrated sulfuric acid. It may also be calcined with soda ash and limestone, and the pulverized product may be treated with water and alkali carbonate solution. S.K.

Mineralizers effective for the crystallization of mullite. TOSHIO NAKAI AND YOSHIO FUKAMI. *Jour. Japan. Ceram. Assn.*, **47** [557] 225–28 (1939).—An X-ray study was made on the effect of the addition of 0.5, 2, and 5% of mineralizers on the formation of mullite in (*a*) a Korean kaolin, (*b*) a mixture of the kaolin and alumina, and (*c*) a mixture of quartz and alumina, with the following results: (1) 11 compounds (lime, lithia, Na tungstate, Cd oxide, magnesia, Bi subnitrate, litharge, ammonium molybdate, boron oxide, Mn dioxide, and cupric oxide) were effective; (2) in every case, the temperature at which mullite crystals were formed was lowered by 50° to 200°C.; (3) each mineralizer seems to have temperatures at which it is most effective. The compounds of Mo and B are most effective at relatively low temperatures. Cupric oxide is effective at both lower and higher temperatures. Manganese dioxide is most effective at higher temperatures, although it is moderately effective at lower temperatures. Sodium tungstate is moderately effective in a wide range of temperatures. Lime, lithia, and magnesia are similar to manganese dioxide in regard to temperature but less effective. Cadmium oxide, bismuth subnitrate, and litharge are least effective for all temperatures. The temperatures in the experiments ranged between 900° and 1100°C. for *a*, 1250° and 1400° for *b*, and 1300° and 1450° for *c*. S.K.

Minerals formed by the reaction of open-hearth slags with the dolomite hearth bottom at high temperatures. B. PINES AND G. KUSHTA. *Stal*, **1936**, No. 7, pp. 47–59; *Jour. Iron & Steel Inst.*, **136** [2] 3A (1937).—The reaction of dolomite with open-hearth slags at high temperatures was investigated by (*a*) laboratory experiments and (*b*) analyzing samples from the hearth. The investigation included X-ray analysis, analytical determination of the free CaO, petrographic analysis, and determination of the refractoriness. Two kinds of slags were used in *a*, with 20% FeO and with 9% Fe_2O_3. Mixtures of 5 to 50% of slag with 95 to 50% of dolomite were heated to 1380° to 1650°C. The minerals formed were Ca_2SiO_4, $Ca_2Fe_2O_5$, $MgAl_2O_4$, $MgFe_2O_4$, and $MgCaSiO_4$. Free MgO (periclase) was always present; with less than 20% of slag, free CaO also occurred. Spinels were present with less than 30% of slag. Ca_2SiO_4 was present in the β form; this form is not stable at low temperatures and goes slowly over to the γ form. This process causes the disintegration of the dolomite hearth bottoms. The petrographic investigation showed that the grains of CaO and MgO are cemented by the silicates and spinels; this explains the primary hardening of the hearth bottoms by the action of slags. The agglomerations formed by this reaction are refractory even up to 1880°C. The wear of the hearth bottom is caused by a continued reaction with the slags, which converts the dicalcium silicate and ferrite into the monocalcium compounds which fuse at low temperatures and are washed away by the slags.

Modulus of elasticity of magnesite refractories: XIII, Method of improving mechanical strength of unfired magnesite refractories at ordinary and high temperatures. SEIJI KONDO AND HIROSHI YOSHIDA. *Jour. Japan. Ceram. Assn.*, **47** [553] 15–17 (1939).—A mixture of 80 or 100 parts of a pulverized clinker and 20 or 0 parts of a pulverized caustic-burned magnesite was, on the addition of an aqueous solution of dextrin, Mg chloride, and Mg sulfate, pressed into test pieces under a pressure of 1000 kgm. per sq. cm. The test pieces were examined for compressive strength after one week, on drying, on heating at temperatures ranging from 100° to 1160°C., and on firing to cone 16, with the following results: (1) the temperature at which the compressive strength of each specimen is lowest was lowest with dextrin, medium with Mg chloride, and highest with Mg sulfate; (2) the range of temperature at which the sulfate specimens showed the lowest strengths was narrow; (3) test pieces made of the pulverized clinker and a solution of the sulfate showed the minimum hot compressive strength of 294 kgm. per sq. cm. They can probably be used without firing. They showed a linear firing shrinkage of about 5%. Shrinkage may be reduced by half, however, by introducing coarse grain of the clinker up to about 50%. **XIV, Chemical composition versus spalling character.** *Ibid.*, [555] 131–35.—An introduction of 5 parts of alumina to 95 parts of pulverized magnesite clinker was remarkably effective in reducing the spalling tendency of the refractories. The aluminous test pieces were fired to cones 12 to 28 with a result that they had to be vitrified at cone 16 and higher. The spalling tendency of test pieces made of varying amounts of coarse grain of the clinker and the fine aluminous powder was determined. Spalling tendency and lowering of the modulus of elasticity were examined with five other Manchurian magnesites. Specimens made of a pulverized compound clinker and auxiliary constituents of magnesite (silica, alumina, ferric oxide, and lime) were also examined for spalling tendency. The following conclusions seem to be justified by the results of the experiments: (1) an addition of silica and lime is detrimental, if some remains in the free state; (2) an addition of ferric oxide, manganic oxide, rutile, strontium sulfate, barium fluoride, and barium sulfate increases the spalling tendency; (3) when alumina and chromic oxide exceed definite amounts, the elasticity of the fired specimens is abruptly increased and their spalling tendency is suddenly lowered; (4) the spalling tendency of specimens containing effective amounts of alumina and chromic oxide decreases with a rise in firing temperature; (5) the effect of chromic oxide is shown at a higher firing temperature than that of alumina; (6) the effective amount of alumina is not affected by an introduction of 10% of ferric oxide or silica, but it varies if a small amount of lime coexists; (7) when the coarse grain of a clinker is bonded with its fine powder with added alumina, specimens containing about 35% or less of the fine powder are inferior to those containing the powder alone; (8) specimens with an addition of 5% of alumina and 1.5% of lime vitrify better, are more resistant to thermal shock, and are richer in load-bearing power compared with specimens with an addition of 5% of lime and 10% of ferric oxide. For Parts **II–III** see *Ceram. Abs.*, **17** [3] 104 (1938); Parts **I** and **IV**, *ibid.*, [2] 73. S.K.

Preparation and properties of some synthetic spinels. W. HUGILL. *Iron & Steel Inst., Special Rept.*, No. 26, pp. 201–204 (1939).—Spinel ($MgAl_2O_4$), picrochromite ($MgCr_2O_4$), and chromite ($FeCr_2O_4$) were prepared by dry crystallization at 1550°C., using 5% boric oxide as a mineralizer. Magnesioferrite ($MgFe_2O_4$) was prepared in a similar manner at 1200°C. in a Hirsch furnace. Attempted synthesis of hercynite ($FeAl_2O_4$) by similar methods failed, resulting in a ferric oxide-corundum solid solution. The synthetic spinel, picrochromite, and chromite showed no signs of fusion at cone 35 to 36 (1770° to 1790°C.). Magnesioferrite squatted at cone 26 to 27 (1580° to 1610°C.) with marked development of magnetite as disclosed by microscopic study. Pure magnesioferrite appears unstable at its squatting point, the ferric oxide set free in the dissociation immediately decomposing to form magnetite and oxygen because the temperature is above the stability range of ferric oxide. Spinel, chromite, and picrochromite are nonmagnetic to a horseshoe magnet; magnesioferrite is magnetic, and no distinction was observed between magnetite and magnesioferrite in their magnetic properties. Magnetic separation of magnetite from a naturally occurring hercynite-magnetite association indicates that hercynite is nonmagnetic. Color (in bulk and under the microscope), powder density, and refractive index of the synthetic crystallizations are tabulated, and further measurements of the properties of these spinels are proposed. P.S.D.

Production of alumina. RUDOLF SEIDEN. *Ind. Eng. Chem., News Ed.*, **14** [21] 435 (1936); see "Alumina . . .," *Ceram. Abs.*, **17** [2] 69 (1938). F.G.H.

Progress report of investigations for the Blast-Furnace Refractories Panel. ANON. *Iron & Steel Inst., Special Rept.*, No. 26, pp. 477–78 (1939).—Blast-furnace refractories are being studied by (1) field observations on blast-furnace plants, and (2) fundamental laboratory investigations of blast-furnace refractories. Current studies and future plans are briefly outlined and discussed. P.S.D.

Progress report of investigations for the Open-Hearth Refractories Joint Panel. ANON. *Iron & Steel Inst., Special Rept.*, No. 26, pp. 213–15 (1939).—Recent and future work on open-hearth refractories is outlined. P.S.D.

Proposal for revision of the specification for refractories of cement rotary kilns. COMMITTEE ON SPECIAL REFRACTORIES. *Jour. Japan. Ceram. Assn.*, **47** [558] Supp. 3–10 (1939).—The investigation of the refractories of cement rotary kilns, the progress of the special committee, linear shrinkage on reheating, and a proposed revised specification for refractories are described. The refractories are classified as *A* to *F*. The allowable deviations in size are ±1.5% in length and width and ±2.5% in thickness. The minimum contents of alumina are *A* 45, *B* 40, *C* 35, *D* 30, and *E* and *F* 25%. The lowest P.C.E. is *A* 34, *B* and *C* 32, *D* and *E* 30, and *F* 26. Absorption is *A* to *E* 12% and *F* 11%. The maximum linear shrinkage on reheating for 4 hr. at 1410°C. is −0.7% for *A* and *B*, and that at 1200°C. is ±0.2% for *C* to *F*. S.K.

Proposal for the revision of the standard method of determining refractoriness. COMMITTEE ON REFRACTORINESS. *Jour. Japan. Ceram. Assn.*, **47** [558] Supp. 1–2 (1939).—The proposed method contains the following revisions: (1) the specimen is ground to pass through a wire gauze sieve with openings of 0.30 mm.; (2) the ground material is formed into truncated equilateral cones whose upper and lower sides and height are 3, 7, and 30 mm., respectively; (3) standard and test cones are set up on a refractory plaque, a face making an angle of 80° with the plaque and having 4 mm. of its lower end in the plaque; (4) the intermediate cone equivalent is shown, e.g., cone 34 to 35. S.K.

Proposed standard nomenclature of various sections of open-hearth steel furnace. OPEN-HEARTH REFRACTORIES JOINT PANEL. *Iron & Steel Inst., Special Rept.*, No. 26, pp. 211–12 (1939).—Open-hearth furnace nomenclature is approached from two viewpoints: (1) indication of furnace positions for the purpose of locating test panels, etc., and (2) allocation of brick usage so that useful information may be collected. A tabular description of individual parts of the open-hearth furnace is correlated, by numbers, with complete line drawings of a typical furnace. P.S.D.

Refractories. ALAN STEIN. *Jour. West Scot. Iron & Steel Inst.*, **47** [1] 3 (1939–40).—S. discusses the types of brick used in furnaces in the iron and steel industry and the test methods most generally used. The use of 9- x $4^1/_2$- x 3-in. brick is increasing gradually in preference to the standard 9- x $4^1/_2$- x $2^1/_2$-in. size; this is also true in countries outside of the United Kingdom. B.C.R.

Refractories for metal-melting furnaces. TOKIJI ISHIKAWA. *Jour. Japan. Ceram. Assn.*, **47** [558] Supp. 11–14 (1939).—Silica brick for an open-hearth furnace must have a refractoriness of cone 33 and higher; the allowable deviations in dimensions are ±2% in length and width and ±2.5% in thickness. Silica brick for the roof and ports must melt into a viscous liquid. S.K.

Refractories used in lime burning. R. P. HEUER AND L. J. TROSTEL. *Pit & Quarry*, **29** [2] 48–53 (1936); *Chem. Abs.*, **32**, 6416 (1938).—Improvement in high heat duty fire-clay brick has resulted from elimination of some or all of the usual plastic or bond clay. Superduty fire-clay brick are made of a higher proportion of flint clay than formerly and have high density and volume stability. SiO_2 brick are more resistant to CaO slagging than fire-clay brick but have low spalling resistance. The outstanding development in the field of high-Al_2O_3 refractories is the production of sillimanite brick consisting chiefly of crystalline mullite. The increase of the spalling resistance of magnesite brick has increased their use.

Refractory concrete for lining lids of open-hearth and electrical furnaces. D. A. NAZAROVA. *Ogneupory*, **6** [12] 1679–81 (1938).—An attempt to replace lids of windows or apertures (through which the raw materials are introduced into the furnace) made out of grog brick by refractory concrete lids was successful; the latter type possesses much greater stability. M.V.C.

Sawdust lightweight refractories. D. YA. KHIMOCHKO AND V. S. ARTAMONOV. *Ogneupory*, **6** [12] 1649–51 (1938).—By increasing the sawdust content (from 60 to 70% by volume), which is used in place of grog, it was possible to produce lightweight refractory brick. M.V.C.

Service of refractories in copper-melting furnaces. N. I. VORONIN. *Ogneupory*, **7** [4] 237–45; [5] 329–32 (1939).—The service of refractories in reverberatory furnaces and converters of copper-melting furnaces is described. On the basis of microscopical and macroscopical studies, chemical analysis, and ceramic investigations, V. discusses the causes of the destruction of refractory linings. Silica brick in the crowns of reverberatory furnaces is destroyed mainly by the interaction of the brick with the dust of the batch and vapors of the oxides of copper and other metals. Dust also has an abrasive effect. Silica brick is partially transformed into tridymite, which is also recrystallized. Magnesite refractories used in converters of copper-melting furnaces are destroyed by the oxidation of sulfur and iron and the slagging of the latter. The lining in Pierce and Smith converters is more durable than that in "Gret-Folls" converters, whose temperature fluctuates greatly. M.V.C.

Service of roofs of electric furnaces and the production of Dinas brick in Verchissetsk. A. T. JAK AND D. F. BURDAKOV. *Kachestvennaya Stal*, **1936**, No. 8–9, pp. 42–46; *Jour. Iron & Steel Inst.*, **136** [2] 123A (1937).—Particulars are given of the experience gained in Verchissetsk in the production of Dinas brick and their use for the construction of roofs of electric furnaces.

Suitability of lateritic bauxite for refractory purposes. D. SWARUP. *Indian Ceramics*, **2** [1] 38–40 (1939).—Experiments were undertaken to determine the properties of Indian bauxite and to test its suitability as a refractory material for metallurgical furnaces. A comparison of the properties of bauxite with those of other refractory materials shows that its greatest drawbacks are its high shrinkage and lack of binding power. Porosity, however, can be overcome by adjusting the proper binding material. Shrinkage can be overcome by first firing the bauxite at a high temperature and then making the brick. It may prove a suitable refractory if a proper binding material is employed, e.g., clay, lime, silica, magnesia, plaster of Paris, etc. Its chief advantages over ordinary refractories are its resistance to slags and mechanical erosion and its neutral character which makes it suitable for both acid and basic furnaces. A.P.S.

Thermal capacity of refractories at high temperatures. Z. E. LOBANOVA. *Ogneupory*, **7** [1] 17–22 (1939).—The mean thermal capacity of various refractory materials at high temperatures was studied. On the basis of experiments, L. concludes that not all processes occur during firing which could have taken place in the materials; therefore, several refractory properties, including heat capacity, change during their service at high temperature. M.V.C.

Thermal spalling of magnesite refractories. S. KONDO AND H. YOSHIDA. *Jour. Japan. Ceram. Assn.*, **46**, 4–8 (1938); *Jour. Soc. Glass Tech.*, **22** [90] 88A (1938).—An air quenching test is preferred because of errors involved in water quenching introduced by the slaking of the magnesite by the steam generated.

Use of magnesium chloride in the production of magnesite refractories. G. M. TAZITDINOV. *Ogneupory*, **6** [12] 1651–56 (1938).—Experiments in the production of magnesite brick containing magnesium chloride are discussed. By introducing 0.4 to 0.7% magnesium chloride

into the mix, unweathered magnesite can be used in the manufacture of magnesite refractories. M.V.C.

PATENTS

Combustion chamber and arch. F. M. Miller (General Refractories Co.). U. S. 2,192,752, March 5, 1940 (March 8, 1937).

Construction of mortarless refractory brickwork. Österreichische Magnesit A.-G. Brit. 517,443, Feb. 14, 1940 (July 28, 1937); addition to 468,341.

Manufacture of refractory material. J. G. Stein & Co., Ltd., and J. F. Hyslop. Brit. 517,908, Feb. 21, 1940 (Sept. 5, 1938).

Refractory blocks for the checkerwork of furnaces for industrial purposes. A. Lermer. Brit. 517,570, Feb. 14, 1940 (July 26, 1938).

Refractory burner throat. A. W. Anderson (Peabody Engineering Corp.). U. S. 2,192,682, March 5, 1940 (Nov. 16, 1938).

Terra Cotta

Low-fire glazes for roofing tile. Yoshio Mizuno. *Jour. Japan. Ceram. Assn.*, **47** [558] 294–97 (1939).—A popular bluish green glaze for roofing tile in the province of Mikawa is made of frit 55, feldspar 47, quartz 10, and cupric oxide 4.5; the batch of the frit is borax 38, feldspar 5, soda ash 12, limestone 14, kaolin 4, and quartz 27. M. succeeded in preparing various glazes with raw borax for a firing temperature of 1000° to 1050°C.; satisfactory bluish green glazes were obtained with raw borax 50 to 40, soda ash 10, feldspar 20, quartz 15, limestone 5, and cupric oxide 3 to 4 parts. S.K.

Whiteware

Apparent defects in electroporcelain. S. Jagadeeshan. *Indian Ceramics*, **2** [1] 34–37 (1939).—From his experience in the Mysore Government Porcelain Factory, Bangalore, J. discusses defects such as specks, flowing or running of the glaze, lamination cracks, glaze crazing, contraction, drying cracks, and mechanical weakness together with browned articles, flashed articles, warped articles, damaged articles, and refiring articles. Their causes and remedies are given. See *Ceram. Abs.*, **19** [3] 70 (1940). A.P.S.

Defects in earthenware. Brindaban Chandra Pal. *Indian Ceramics*, **1** [4] 137–39 (1938).—P. discusses (1) chief raw materials available in India for the manufacture of earthenware, (2) various defects arising in earthenware manufacture (crazing, scaling, pinholes, feathering, rolling dryness, and spitout) and their causes and cure, (3) various tests to check the tendency of the glaze to crack, and (4) reliability of the glaze in general use. A.P.S.

Discharge lag in solid insulation. Robert Strigel. *Wiss. Veroffent. Siemens-Werken*, **18** [1] 101–19 (1939).—Glass, mica, and porcelain are investigated. J.M.N.

Electroporcelain. M. Meccai. *Indian Ceramics*, **1** [4] 123–25 (1938).—M. briefly outlines the process of manufacture. A.P.S.

Internal structure of Japanese pottery. Toshio Nakai and Yoshio Fukami. *Jour. Japan. Ceram. Assn.*, **47** [559] 347–51 (1939).—Tableware of seven chief porcelain-producing districts, two porcelain plants, and a china plant and an electrical insulator were examined for chemical composition, X-ray diffraction, and specific gravity. The results were as follows: (1) chemical composition, silica 68 to 80, alumina 16 to 26, and alkalis 3.5 to 6%; (2) crystals present, quartz, mullite, and cristobalite; (3) specific gravity, 2.41 to 2.56. The combined data aid in determining the true nature of the products and, to some extent, the process of manufacture. S.K.

Investigation of the volatility of glaze constituents by the use of the spectrograph. H. C. Harrison, W. G. Lawrence, and D. J. Tucker. *Jour. Amer. Ceram. Soc.*, **23** [4] 111–16 (1940).

Investigations on vitreous china bodies: II. E. Denninger. *Ber. Deut. Keram. Ges.*, **19** [10] 427–31 (1938).—The elasticity of the glaze is an important factor. The vitreous china bodies investigated in Part I were tested with a raw glaze which proved satisfactory in practice. The mix, Seger formula, and chemical composition are as follows:

	K feldspar	Na feldspar	Marble	Magnesite	ZnO	Kaolin	Sand	Tin oxide
Mix (%)	12.55	18.65	15.11	5.83	10.45	9.50	25.58	2.33
	K_2O	Na_2O	CaO	MgO	ZnO	Al_2O_3	SiO_2	SnO_2
Seger formula	0.055	0.090	0.370	0.170	0.315	0.233	2.079	0.038
Chemical composition	2.12	2.20	8.46	2.79	10.45	9.67	50.97	2.33

The glaze flows at cone 8, but can be used up to cone 10. For the thermal expansion experiments, the glaze was melted down at cone 8 and cooled normally. It was then ground to powder, moistened with dextrin, and formed into bars 3 mm. in diameter and 60 mm. long. The rods were fired to about 1000° in an electric furnace and then slowly cooled. During the measurement of the thermal expansion the temperature rose 20° per 3 min. to 865°, when a rather rapid softening took place. The thermal expansion curves show that the expansion of the glaze up to the softening point was, in every case, greater than that of the bodies, so that the glaze was permanently under tension and crazing was to be expected. To determine how far this conclusion was borne out in practice, all the glaze specimens were stored at room temperature for about 2 years and were then again examined for crazing. The results tabulated show that pure feldspar bodies did not craze. These bodies are nearest the glaze in their thermal expansions. Bodies with an addition of 2 to 4% marble were resistant to crazing, but the addition of 8% marble caused crazing. This confirms practical experience but indicates that there is a limit to the marble content. Crazing appeared only on bodies containing more than 4% marble. Similar results were obtained with bodies containing magnesite and dolomite. Tension measurements by the Steger method showed that the stresses had almost disappeared. The noncrazing property of the glaze on some of the bodies is therefore due, to a large extent, to the elasticity of the glaze. For Part I see *Ceram. Abs.*, **16** [1] 27 (1937). E.J.V.

Magnesian porcelain, steatite: VIII. Shoichiro Nagai and Akira Naruse. *Jour. Japan. Ceram. Assn.*, **47** [557] 238–43 (1939).—The effects of various oxides are dealt with. Talcs of Korea, Manchukuo, and the Shantung Peninsula of North China are very pure and are therefore excellent materials for steatite. The addition of 5 alumina, 10 to 15 zinc oxide, 5 barium oxide, or 5% litharge to pulverized Manchurian talc is advantageous; titania and chromic oxide are ineffective. For Part VII see *Ceram. Abs.*, **16** [7] 211 (1937). S.K.

Promotion of interfacial reactions to counteract crazing. Robert M. Campbell. *Bull. Amer. Ceram. Soc.*, **19** [3] 91–92 (1940).

Titanium compounds: IV. Shin-ichi Suzuki. *Jour. Japan. Ceram. Assn.*, **47** [553] 8–12 (1939).—S. investigated the physical and electrical properties of 17 bodies

consisting of 0.007 to 0.047 KNaO, 0.088 to 0.095 CaO, 0.057 to 0.072 MgO, 1.00 Al_2O_3, 0.007 to 0.035 Fe_2O_3, 2.410 to 5.842 SiO_2, and 0.449 to 3.475 TiO_2 with the following results: (1) the minimum value of tan δ is shown for a body containing 2.6 mol. of TiO_2; for bodies rich in alkalis, it occurs at 0.5 to 0.6 mol. of TiO_2, indicating that the effect of the titanium oxide is reduced by the change of the oxide into a basic substance; (2) tan δ and the dielectric constant decrease with a rise in firing temperature only to the point where the bodies are not overfired; (3) a body containing 0.007 KNaO, 0.088 CaO, 0.069 MgO, 1.000 Al_2O_3, 0.007 Fe_2O_3, 2.731 SiO_2, and 2.612 mol. of TiO_2 showed a tan δ of 9.1×10^{-4} when it was fired to cone 10. **V–VI.** *Ibid.*, [555] 123–30.—For the purpose of obtaining a satisfactory insulator for high-frequency current, firing and electrical examinations were made of 150 bodies in the systems (*a*) kaolin–feldspar–quartz–titania, (*b*) kaolin–feldspar–quartz–limestone–alumina–titania, (*c*) talc–feldspar–kaolin–titania, and (*d*) kaolin–feldspar–quartz–limestone–titania. Thermochemical considerations are given for the reduction of titania to Ti_2O_3. S. succeeded in obtaining 5 bodies in system *d* which surpassed steatite as shown by the following tables:

TABLE I

MOLECULAR COMPOSITION

No.	Soda	Potash	Lime	Magnesia	Alumina	Silica	Titania
IP1	0.030	0.027	0.479	0.071	1.000	3.020	0.243
IP2	0.029	0.026	0.669	0.069	1.000	2.700	0.243
IP3	0.029	0.029	0.864	0.070	1.000	2.373	0.281
IP11	0.058	0.042	0.525	0.069	1.000	3.660	0.272
IP12	0.056	0.041	0.723	0.071	1.000	3.260	0.270

TABLE II

No.	Absorption (cone 14)	Dielectric constant	Dielectric loss (10^{-4})
IP1	0.49	5.11	6.0
IP2	0.22	5.28	7.9
IP3	0.00	4.40	9.8
IP11	0.00	7.46	13.9
IP12	0.00	7.11	10.6

VII. *Ibid.*, [557] 243–48 (1939).—The methods of obtaining insulators with a high dielectric constant were considered by classifying them into vitrified rutile and titanate bodies. Forty-eight new bodies containing ammonium phosphate as a mineralizer were prepared and fired to cones 10 and 12. Every specimen was tested for dielectric constant and tan δ. The effects of admixtures and firing temperature were also studied. See "Ceramic....," *Ceram. Abs.*, **18** [1] 27 (1939). S.K.

PATENTS

Electrical insulator. V. F. HAMMEL. U. S. 2,191,152, Feb. 20, 1940 (Aug. 31, 1934; June 25, 1935).

Method and apparatus for manufacturing pottery ware. W. J. MILLER. U. S. 2,191,857, Feb. 27, 1940 (May 2, 1935).

Method and apparatus for testing spark plugs. M. F. PETERS AND H. K. KING. U. S. 2,192,932, March 12, 1940 (April 12, 1939).—A method of testing spark-plug insulators comprises the steps of immersing the core assembly of a spark plug in an electrolyte, wiping the electrolyte from the surface of the insulator, impressing across the exterior of the insulator and the central electrode of the assembly a voltage of such magnitude as to cause a measurable current leakage if the insulating qualities of the insulator have been impaired, and indicating the amount of current leakage and the heating of the core assembly caused thereby.

Screened spark plugs. R. BOSCH GES. Brit. 517,939, Feb. 28, 1940 (Sept. 16, 1937); addition to 482,662.

Spark plug. A. A. ST. JOHN (Frank U. Turcotte). Can. 385,951, Dec. 26, 1939 (June 6, 1938). G.M.H.

Spark-plug protectors. J. O. HODGKINSON. Brit. 518,095, Feb. 28, 1940 (Aug. 15, 1938); addition to 476,-789.

Spark plug with umbrella. J. F. BARR (Champion Spark Plug Co.). U. S. 2,190,765, Feb. 20, 1940 (Jan. 21, 1939).

Equipment and Apparatus

Apparatus for the photometric sorting of sand. L. H. BERTHOIS AND P. M. DUFFIEUX. *Compt. Rend.*, **209** [24] 889–91 (1939).—The sorting of sand by sifting requires samples of at least 150 gm. and takes a fairly long time. If smaller samples only are available, direct determination of grain size in a microscope is unsatisfactory and tedious. A. describes a photometric arrangement in which the sample is placed on an object glass under a microscope and illuminated by a strong, bright light; the light flux passed through the grains is measured by a photoelectric cell; by comparing the flux without interference with that passing through the grain by means of the current in the photoelectric circuit, the sand can be sorted quickly and exactly. The apparatus and method are described in detail. The photoelectric cell is preferably of the Fe-Se type in connection with a galvanometer of about 7×10^{-9} amp. sensitivity for 1-mm. deflection; the deviation is practically proportional to the incident light. M.H.

Application of temperature-measuring equipment to the measurement of gas temperatures. S. MATTHEWS. *Jour. Inst. Fuel*, **12** [64] S72–75 (1939).—M. considers recent developments in the field of industrial gas temperature measurement with special reference to problems relating to the use of radiation pyrometers. H.E.S.

Centrifuge method of investigating the variation of hydrostatic pressure with water content in porous materials. R. J. SCHAFFER, J. WALLACE, AND F. GARWOOD. *Trans. Faraday Soc.*, **33**, 723 (1937); *Trans. Ceram. Soc.*, **36** [7] 60A (1937).—The hydrostatic pressure to which water held in the pores of a porous material is subjected varies with the curvature of the liquid film. It is related to the moisture content in a manner depending on the structure of the particular material, and this relation has been used to characterize the capillary properties of porous materials such as stone, brick, or soil. Investigations on the centrifuge method and a comparison of the results obtained by the hydrostatic and centrifuge methods using Portland stone as the porous material are dealt with. A specially designed centrifuge is described.

Combination centrifugal and gravity air separator. J. HEYD. *Tonind.-Ztg.*, **61** [77] 860–62; [78] 871–73 (1937).—Types of air separators which combine the use of gravity and centrifugal force for the sizing of material are described. Gravity is best adapted to the separation of coarse particles between 0.25 and 1.5 mm. in diameter, and centrifugal separation is best for finer sizes. Illustrated. W.K.

Continual observation of changes in weight at oven temperatures. A. C. BECKEL AND A. G. SHARP. *Ind. Eng. Chem., Anal. Ed.*, **12** [1] 45–47 (1940).—An apparatus for studying drying rates is described and illustrated. F.G.H.

Corrosion-resistant ceramic filter plates. Kh. Tseitlin. *Novosti Tekhniki*, **5** [46–47] 38–39 (1936); *Chem. Abs.*, **31**, 2045 (1937).—Filter plates having a velocity of filtration of 41 to 91.7 liters per sq. m. per hr. under a pressure of 100 mm. of Hg were prepared in the Kineshma ceramic plant. The powdered plate, after being boiled with 90% H_2SO_4, lost 7.90% of its weight. The yield point, equal to 10.37 to 13 kgm. per sq. cm., permits the use of these plates in the aniline dye industry.

Deairing of clay in the ceramic industry. G. Lanorville. *Nature* [Paris], No. 3050, pp. 353–55 (1939).—L. reviews the advantages resulting from the deairing of clays and describes apparatus commonly used in the ceramic industry for that purpose. R.W.D.

Desirability of adsorption dehumidifiers in air conditioning. B. P. Fonda. *Heating & Ventilating*, **35** [5] 37–39 (1938).—The process of removing moisture from air without reducing the air temperature to the dew point is attracting more attention. The present field for this method is largely confined to situations where the moisture load is great relative to the total heat to be removed. Adsorptive dehumidification has been used in dental porcelain manufacturing, showcase glazing, and safety glass making. F.S.M.

Determining the moisture content in ceramic bodies. S. N. Makarin. *Ogneupory*, **6** [6] 1277–84 (1938).—The latest methods used for determining moisture are discussed. Methods used in the pulp and paper industries, which are as important in these industries as in ceramics, are analyzed. Some of these methods may be used successfully in the ceramic industry with little modification. See "Apparatus for determination . . .," *Ceram. Abs.*, **18** [8] 219 (1939). M.V.C.

Developments in dry mixing of ceramic bodies. F. A. Fix. *Bull. Amer. Ceram. Soc.*, **19** [3] 90–91 (1940).

Electricity in the pottery industry. N. A. Smith. *Metropolitan Vickers Gaz.*, **18**, 200–209 (1939).—The processes involved in the manufacture of domestic pottery are described. At each stage the most suitable electric equipment, particularly the motor, is specified. To withstand the dust and splashes and overcome the large initial torque common in such pottery machinery as blungers, the wet pan, or a group of potter's wheels, a totally inclosed fan-cooled slip-ring motor is best. Alternatives for smaller equipment or that needing less starting torque include a squirrel-cage motor with an oil-immersed star delta starter and clutch. The value of good lighting is also stressed. Illustrated. L.R.B.

Errors in gas-temperature measurement. A. F. Webber. *Jour. Inst. Fuel*, **12** [64] S56–58 (1939).—In a hot blast main at an iron works, a substantial error was shown in conditions which should have favored accuracy. In a narrow water-cooled flue, the error, though expected, was of unforeseen magnitude, i.e., 1000°F. H.E.S.

Factors affecting physical properties of a dry-mixed body. Carl H. Rapp. *Bull. Amer. Ceram. Soc.*, **19** [3] 87–89 (1940).

Industrial exhaust ventilation. B. F. Postman. *Amer. Jour. Pub. Health*, **30** [2] 149–61 (1940).—P. describes in detail the technique and equipment required for the removal of such dusts and fumes as silica, lead, benzol, and acrolein. B.C.R.

Industrial temperature measurement by means of thermocouple pyrometers. R. Vernier. *Métallurgie*, **71** [12] 11–14 (1939).—V. classifies errors in thermocouple reading as those caused by the weld not being at the proper point of measurement, those due to the thermocouple, those due to the wiring, and those due to the instrument. V. gives data on resistance for different diameters of iron-constantan, Chromel-Alumel, and Pt-Pt Rh couples and for the extension leads when used with copper-constantan, Chromel-Alumel, iron-constantan, and Pt-Pt Rh couples. J.M.N.

Manufacture of Seger cones: I. Toshio Nakai and Yoshio Fukami. *Jour. Japan. Ceram. Assn.*, **47** [557] 233–37 (1939).—Experiments on feldspars are reported. The diffraction patterns of orthoclase, anorthoclase, albite, oligoclase, andesine, labradorite, and anorthite are given and discussed. The true specific gravities of seven specimens in the crystalline and glassy states are 2.575 to 2.785 and 2.371 to 2.703, respectively. The change of true specific gravity on heating the specimens at temperatures varying from 1050° to 1300°C. is given. The result indicates the existence of a eutectic between orthoclase and albite. The results of an experiment on the effect of magnesia, lime, borax, litharge, quartz, and kaolins on the melting point of orthoclase and albite are shown graphically. S.K.

Measurement of flame temperatures. G. Ribaud, Y. Laure, and H. Gaudry. *Jour. Inst. Fuel*, **12** [64] S18–30 (1939).—The significance of flame temperature and the principles of the different methods of measuring it are discussed. Methods employing an instrument introduced into the flame are considered, including the suction pyrometer method, the extrapolation to zero size method, and heated wire methods. Optical methods for partially opaque luminous flames are described, including that of Kurlbaum, improvements on his methods, and a photographic method. Nonluminous flames are discussed, particular attention being given to Féry's spectral line immersion method, its errors, and improvements on it. The problems of measuring fluctuating flame temperatures and temperatures in an internal-combustion engine are dealt with. A chemical method and one depending on thermal conductivity are mentioned. H.E.S.

Measurement of gas temperature in the chemical industry. J. C. Swallow. *Jour. Inst. Fuel*, **12** [64] S68–72 (1939).—S. deals with the choice of pyrometers (mercury in glass, mercury in steel, thermocouples, resistance thermometers, radiation pyrometers) and their relative merits for different services. Attention is paid to problems of measuring gas temperatures over 1200°C. and to the effects of sensitivity and lag on automatic temperature control. Refractories for use with pyrometers and the use of metal protective sheaths are discussed. H.E.S.

Measurement of surface temperature. Fritz Lieneweg. *Arch. Tech. Messen*, **6** [74] 99–100T (1937).—The rapid measurement of surface temperatures is accomplished with radiation pyrometers. They are used with thermocouples and photocells (alkali-metal cells). L. discusses their application and describes additional equipment for indicating and recording. J.M.N.

Measurement of temperature of producer gas. M. W. Thring. *Jour. Inst. Fuel*, **12** [64] S58–61 (1939).—To test calculations on the temperature drop in producer-gas mains it was necessary to know how closely readings of thermocouples in the gas corresponded to the actual gas temperature. A special assembly of three bare thermojunctions used for this purpose gave satisfactory results after certain precautions were taken. H.E.S.

Modern pyrometry: II. H. Hirst. *Chem. Eng. & Mining Rev.*, **32** [374] 52 (1939).—The operation of the electrical resistance thermometer, used for measuring temperatures to within 0.01°C., depends on the fact that the electrical resistance of a metal, platinum being generally used, increases with rise in temperature. Small currents of 0.01 to 0.1 amp. are used. **III.** *Ibid.*, [375] 115.—Both the theoretical and practical considerations of radiation and optical pyrometers are discussed. Radiation pyrometers should give the same indicated temperature when the distance of the pyrometer from the source of radiation is varied considerably. Such will be the case if the image of the source is never smaller than the absorbing surface of the pyrometer. The construction and operation of the Féry, Foster, and Thwing instruments are described. The use of a closed-end tube for sighting purposes is recommended, as it eliminates the errors resulting from the presence of smoke and dust in the furnace. The more universal use of optical pyrometers is due largely to the lessened need of perfect black-body conditions. Mention is made of both the disappearing filament and polarizing pyrometers; the former is rapidly replacing the latter due to its less intricate construction and greater ease of manipulation. The calibration of radiation and optical pyrometers by means of a platinum-wound furnace specially constructed to provide black-body radiation is also

discussed. Because of the gradual decrease in the brightness of the lamp with age, optical pyrometers should be checked periodically. For Part I see *Ceram. Abs.*, **19** [2] 50 (1940). B.C.R.

Modified aspirating thermocouple for gas temperatures. B. M. LARSEN, G. SIDDALL, AND K. HEINDLHOFER. *Jour. Inst. Fuel*, **12** [64] S55–56 (1939).—A suction pyrometer for gas temperatures up to 2500°F. is dealt with. The radiation shield takes the form of a refractory brick with small channels for the gas. Construction details are given, together with operating results. H.E.S.

Outline of experience with portable-type annealing furnaces. D. E. MCGUIRE. *Iron & Steel Engr.*, **14**, 70–73 (Dec., 1937); *Metals & Alloys*, **9** [8] MA490 (1938).—McG. describes a number of furnaces installed at the Great Lakes Steel Corp., including gas-fired radiant tube types with both horizontal and vertical tubes and oil-fired types with horizontal hairpin-type tubes. In the gas-fired furnaces, the horizontal-tube type is more efficient, easier to control, and more rugged than the vertical-tube type. The principal source of trouble in both types is in the design of bases and inner covers. The latest base design is heavy cast Fe with sand seals formed in the brickwork. The most satisfactory inner cover is of eleven-gauge sheet steel stretched and welded over the top of the inner bar frame. Experimental work to reduce gross weight of the charge in the oil-fired in-and-out style of stationary furnaces is described. Covers of eleven-gauge heat-resisting alloy steel sheets over welded cast-steel frames, with a total weight of 5000 lb. as compared to 20,000 lb. for former cast-steel covers, permit much larger loads to be handled. Tonnage with these furnaces is 22,000 tons of sheets and coils, with a fuel consumption of 9¼ gal. of heavy oil per ton of sheet annealed.

Overcoming thermocouple errors in high-temperature induction furnaces. FRANK DAY, JR., AND HURD W. SAFFORD. *Ind. Eng. Chem.*, **32** [3] 445–46 (1940).—As the exposure of the platinum shield to fumes in the furnace was considered undesirable, a shield of smaller diameter was placed over the insulating tube inside the porcelain protector of the thermocouple and was grounded. This modification also requires less of the costly platinum and prevents its abrasion. It is necessary to have the platinum shield cover only that portion of the pyrometer which is actually in the furnace. F.G.H.

Power-transmission problem in the porcelain industry. MAURER. *Ber. Deut. Keram. Ges.*, **19** [7] 259–71 (1938).—M. discusses the various types of motor transmissions and drives as applied to various phases of the porcelain industry. Illustrated. E.J.V.

Progress, possibilities, and limitations in the beneficiation of clays. G. A. BOLE. *Illinois State Geol. Survey Circ.*, No. 23-C, pp. 11–18 (1938); *Chem. Abs.*, **33**, 826 (1939).

Properties of mixtures of air and saturated water vapor for barometric pressures from 22 to 32 in. of mercury. WILLIAM GOODMAN. *Heating, Piping & Air Conditioning*, **11** [12] 755–56 (1939).—Values are tabulated for temperatures from −40°F. to +200°F. at 27 in. of mercury. J.L.G.

Psychrometric chart, application and theory: VIII. WILLIAM GOODMAN. *Heating, Piping & Air Conditioning*, **12** [1] 6–9 (1940).—G. discusses air mixtures, interpretation of ratio lines, and variable moisture ratios. Eight figures. For Part VI see *Ceram. Abs.*, **19** [4] 96 (1940). J.L.G.

Relation of uniform pyrometer records to uniform products. J. A. DOYLE. *Ind. Eng. Chem., News Ed.*, **18** [4] 135–37 (1940).—Illustrated. F.G.H.

Special high-grade steels suitable for use in the gas industry. M. P. THOMAS. *Jour. Usines Gaz*, **63** [17] 430–42 (1939).—T. presents a review of the subject. R.W.D.

Subscreen particle-size measurements. E. I. SHOBERT. *Rev. Sci. Instruments*, **10** [6] 169–73 (1939).—The apparatus originally described by Wiegner for measuring subscreen particle sizes (from 60 microns down to 1 micron) is discussed with respect to its applications to various ranges of materials and particle sizes. S. discusses a method of simplifying the calculation of particle size from the sedimentation curves which is particularly adapted to powder analysis in connection with powder metallurgy. Methods of applying the sedimentation method to regions where Stokes' law no longer holds are described. H.E.S.

Temperature-measuring instruments. W. BOWEN. *Jour. Inst. Fuel*, **12** [64] S75–80 (1939).—B. reviews modern developments in temperature-measuring instruments, dealing with them according to the principles involved and discussing resistance, thermoelectric, radiation, and optical pyrometers. H.E.S.

Thermoelectric measurement of high temperatures in pressure apparatus. F. BIRCH. *Rev. Sci. Instruments*, **10** [4] 137–40 (1939).—The effect of pressures up to 4000 kgm. per cm.² upon the thermal electromotive force of Chromel-Alumel and Pt-Pt 10% Rh couples has been observed for hot-junction temperatures up to 580°C. The results are presented in curves showing the decrease of e.m.f. as a function of temperature and pressure. H.E.S.

Theory and application of the suction pyrometer. A. SCHACK. *Jour. Inst. Fuel*, **12** [64] S30–38 (1939).—A mathematical theory is developed for suction pyrometers of normal design having two concentric suction tubes. With certain assumptions, this treatment may be used for a pyrometer surrounded by concentric rings of small suction tubes. Experimental results using the various types of instruments are outlined and compared with calculated values. H.E.S.

Tube mill. ANON. *Engineering*, **148** [3858] 681 (1939).—The construction of a completely welded steel tube mill for grinding cement is described. B.C.R.

Use of thermocouples for temperature measurement. M. FISHENDEN. *Jour. Inst. Heating & Ventilating Engrs.*, **7**, 15–22 (March, 1939); *Jour. Iron & Steel Inst.*, **139** [1] 352A (1939).—F. explains the theory and practice of the thermocouple and points out some of the precautions which should be taken to ensure reliable results.

BOOK

Electrical Testing for Practical Engineers. G. W. STUBBINGS. Chemical Publishing Co., New York. 252 pp. Price $3.50. Reviewed in *Science News Letter*, **36** [25] 400 (1939).—S. presents a comprehensive and yet simplified manual dealing with the kind of testing required for the installation and maintenance of electrical plants and machinery. P.G.H.

PATENTS

Apparatus for deairing slip. ATSUJI TERASAKI. Japan. 128,727, March, 1939.—Slip is introduced to the top of a vacuum chamber in which the slip flows in a thin layer on inclined zigzag plates by gravity. The plasticity of a plastic body is improved by the treatment. S.K.

Ball mill. C. G. MCLACHLAN (Dominion Engineering Works, Ltd.). Can. 386,165, Jan. 9, 1940 (Aug. 3, 1937). G.M.H.

Classifier mechanism. C. H. SCOTT (Dorr Co., Inc.). U. S. 2,191,743, Feb. 27, 1940 (Jan. 26, 1938). U. S. 2,191,744, Feb. 27, 1940 (Feb. 16, 1938; renewed Dec. 19, 1939).

Thermocouple. R. R. RIDGWAY (Norton Co.). Can. 386,183, Jan. 9, 1940 (Nov. 17, 1936; in U. S. Nov. 22, 1935). G.M.H.

Kilns, Furnaces, Fuels, and Combustion

Coal-fired kilns invented by Matsumura. JIROKICHI KUMAZAWA. *Jour. Japan. Ceram. Assn.*, **47** [553] 34 (1939).—The coal-fired kilns invented by H. Matsumura, which are now widely used in the prefectures of Aichi, Gifu, and Mie, were derived from Wagner's coal-fired kiln. Wagner's kiln was rectangular and had fireplaces at one side; the products of combustion were drawn from the center of a main flue at the opposite side to a stack. The temperature in the kiln was therefore very nonuniform. Matsumura's kilns have fireplaces at both sides, and the main flue is usually built at each end of the kilns, making the temperature in the kilns very uniform. S.K.

Continuous electric kiln for wall tile glaze firing. R. AND L. G. *Arts du Feu*, 2 [8] 56–57 (1939).—A small electric kiln in Rousies (France) is described. This kiln, being only 10 m. long and having 24 passages and anti-current circulation, is very economical. The quality of the ware equals that of ware from an ordinary tunnel kiln. F.E.V.

Electric tunnel kiln for porcelain firing. P. DE GROOTE. *Arts du Feu*, 2 [7] 29–31 (1939).—The Brown Boveri kiln in Langenthal (Switzerland) for firing hard porcelain is described. Thermal efficiency and cost of production are discussed. An experimental plant in France is suggested. See "Large-type...," *Ceram. Abs.*, **18** [5] 135 (1939). F.E.V.

Expansion strains in the initial firing of ceramic ware. G. E. SIEVERT AND J. MOFFAT, JR. *Jour. Amer. Ceram. Soc.*, **23** [4] 122–24 (1940).

Factors influencing the choice of fuels and kilns in the ceramic industries. J. FOX. *Jour. Inst. Fuel*, **12**, 257–78 (1939).—The factors and problems in firing glazed tile, building brick, stoneware pipes, and miscellaneous refractory goods are reviewed. F. gives a synopsis of firing principles and describes various types of kilns such as the Hoffman ring kiln, Monnier kiln, Dressler car type tunnel kiln, Williamson kiln, and the Woodall-Duckham circular kiln. Notes on the firing of salt-glazed ware in tunnel kilns are also given although they are largely of an experimental nature. Illustrated. H.E.S.

Importance of the nature of the atmosphere in industrial furnaces. M. R. MARTIN. *Jour. Usines Gaz*, **63** [15] 389–403 (1939). R.W.D.

Seger cones: III, Anomalies; IV, Use of cones. M. WINTERER AND R. POPINEAU. *Arts du Feu*, 2 [8] 59–63; [9] 92–94 (1939).—Anomalies in the behavior of cones are described and explained. The method of using cones in intermittent and continuous furnaces and in testing refractory material is described. For Part I see "Pyrometric...," *Ceram. Abs.*, **18** [7] 191 (1939). F.E.V.

Temperature regulation in glass and enamel furnaces. OTTO T. KORITNIG. *Glashütte*, **69** [51] 833–35 (1939).—In measuring and regulating the temperature inside the furnace K. found that incorrect values result from the reflection of the gas current on the pyrometer from the walls and that thermometers are affected by convection. The greater the convection and radiation are in proportion to the heat from the heat source, the more inaccurate the temperature indicated will be. Caution is therefore necessary when the temperature is regulated by instruments. The rule for heat flow and heat radiation teaches that the greater the velocity of the gas and the smaller the diameter of the thermoelement, the smaller is the error of the temperature measurement and the resulting regulation. The errors of measurement can be avoided by the use of suction pyrometers where the hot gases are sucked with great velocity through a thick-walled tube of poor conducting material in which the thermoelement is installed and through which a good heat exchange between the heat flow and the interior of the tube keeps the temperature equal to the actual temperature of the heat source. There are different ways of measuring and regulating temperature; the most common is with the thermoelectric pyrometer. A process which keeps the temperature within ±10°C. in a glass or enamel furnace is sufficient for the highest requirements. The working principle of temperature regulators is as follows: a cylindrical tube, the sensitive element, contains a liquid or gas with low boiling point which vaporizes when exposed to heat. The resulting pressure forces a column of liquid through a capillary tube to a piston or membrane, and the movement is coupled with the regulating valve by a "spindle." When the expansion of a liquid alone is relied on, there is always the danger that the metal "shell" (membrane) which opens or closes the valve will get too much pressure; this method is therefore not accurate enough for use in industry. If the boiling pressure of the liquid is used instead of the expansion of the liquid, the steam presses against the metal part of the regulating valve and guarantees that a temperature within limits of ±1°C. will be maintained. Such a regulator operates as follows: steam is formed by heat acting on the brass tube or sensitive element, and the pressure is transferred through a capillary conduit to a metal shell; here the pressure is checked by a counter spring by which means the regulating valve is partially or entirely closed. When the temperature falls, the steam pressure diminishes, and the counter spring overcomes the pressure on the metal "shell;" the valve opens, and the heat can again enter. For chemically active liquids, steel or a coating of lead or tin is used in place of brass for the sensitive element; different metals are used for different temperature intervals. For temperatures above 250° and a regulation interval up to ±60°, gas is used in the sensitive element, and at temperatures above 800° the tube must be protected by a grog or porcelain casing. The temperature regulator can give reliable service only when the entire length of the tube (sensitive element) is exposed to the heat. Regulators for gas cannot be used for liquids and vice versa. K. explains the construction and intricate adjustment of different types of temperature, time-temperature, and "program" regulators, etc., and their operation and regulating system in heating, drying, boiler, and other installations. M.V.C.

PATENTS

Kiln burner and air supply fitting. C. F. PRIEST. Can. 386,002, Jan. 2, 1940 (April 1, 1939). G.M.H.

Rotary kiln. MIKAEL VOGEL-JØRGENSEN (F. L. Smidth & Co.). Can. 386,365, Jan. 16, 1940 (July 13, 1937). G.M.H.

Geology

Alteration of glasses to montmorillonite. E. A. HAUSER AND H. H. REYNOLDS. *Amer. Mineralogist*, **24** [9] 590–97 (1939).—Montmorillonite was produced by high temperature and high pressure alteration of both a synthetic glass having a composition similar to that of montmorillonite and a natural obsidian under acid, neutral, or basic conditions. The conditions have much more latitude in the case of $Mg(OH)_2$ than in the case of the other alkalis. The obsidian was very stable and yielded a fuller's earth only after 15 days' heating. The montmorillonite produced was nonswelling, and that produced in acid media showed the characteristics of fuller's earth. Attention is called to the possibility of using this method to synthetically produce clays of given characteristics in countries where natural clays are scarce or in those industries where a highly specialized clay is desired in relatively small quantities. F.J.Z.

Ceramic clay in Hawaii. C. K. WENTWORTH, R. C. WELLS, AND V. T. ALLEN. *Amer. Mineralogist*, **25** [1] 1–33 (1940).—Exceptional interest, from the standpoint of the geologist, the student of soils, and the practical craft potter, attaches to the recent discovery of excellent ceramic clay in Hawaii. This clay was first found in 1935 in small deposits in restricted areas near the crest of the Koolan

Range of eastern Oahu. A considerable amount of high-grade pottery has been made from clay from this area during the past three years. It was supposed that clay would be found in topographically similar situations on other islands, and some samples were sent to Honolulu. In the summer of 1938, Wentworth collected samples and made brief examinations of clay localities on east Molokai, west Maui, and Kauai. The occurrence and geologic relations of clays are described by Wentworth, the chemical analyses and discussion are by Wells, and the petrography and mineralogy are by Allen. In addition, in order to define more accurately the ceramic character of the Hawaiian clay, a few practical tests of physical properties were made. These were applied to the three clays used by the Hawaiian Potters' Guild to compare them with two clays known in the U. S. They also furnish, in the practical work of guild members, some rational explanation of the behavior of these clays, which is already familiar from practical experiences. The deposits take the form of thin underlays, always overlain by a well marked humus or peat layer at the modern surface and usually underlain by thin but more or less continuous masses of iron followed by weathered, buff, or brown residuum. In every instance the clay occurs in sloping areas of little relief, remnants of original constructional surfaces of volcanic domes, which receive rainfall of 150 to 400 in. annually but which have long remained free from significant disturbances by erosion or deposition. In elevations ranging from 2500 to 5500 feet, patches of more or less distinctive bog vegetation have developed and are apparently the basis of the reducing conditions under which clay fairly low in iron has been produced. Three complete chemical analyses show the following variable composition: silica 34 to 57, Al_2O_3 22 to 26, and iron oxides 3 to 9%. Most surprising is the figure of 14% TiO_2 in two of the samples. Preliminary petrographic studies indicate the derivation of the clay from basaltic lavas, the feldspar phenocrysts changing to kaolinite and the matrix (originally feldspars and ferromagnesian minerals) changing to illite. Elutriation concentrates from the clay contain plagioclase, ilmenite, and leucoxene. The latter mineral probably accounts for the high TiO_2 which was derived from original ilmenite and titaniferous augite. F.J.Z.

Classification and structure of silicates. H. STRUNZ. *Z. Krist.*, **98**, 60–83 (1937); *Chem. Abs.*, **32**, 2055 (1938). —In addition to the usual main groups based on the arrangement of the SiO_4 tetrahedra, the classification depends upon the presence of cations with 6-coördination (or greater than 6) and on the presence or absence of anions in addition to the SiO_4 tetrahedra (*eingelagerte Anionen*). The structures of some rare silicates are discussed, including narsarsukite (analysis given), trimerite, sarkolite, prismatine, kornerupine, and karpholite. See "Stereochemistry...," *Ceram. Abs.*, **18** [6] 165 (1939).

Cristobalite in southwestern Yellowstone Park. ARTHUR DAVID HOWARD. *Amer. Mineralogist*, **24** [8] 485–91 (1939).—H. describes new occurrences of cristobalite in southwestern Yellowstone Park. Some of the cristobalite was probably formed by reaction between solutions trapped in lithophysae and the cavity wall rock as was proposed by Foshag for the cristobalite of Obsidian Cliff. The remainder may have been formed by reaction between invading solutions and the glass. Inasmuch as aqueous and gaseous solutions are permeating the rocks over the wide areas in Yellowstone Park at the present time, cristobalite may even now be in process of formation. F.J.Z.

Crystal structure of plazolite. A. PABST. *Amer. Mineralogist*, **22**, 861 (1937); *Trans. Ceram. Soc.*, **36** [9] 72A (1937).—The crystal structure of plazolite, $3CaO \cdot Al_2O_3 \cdot 2(SiO_2 \cdot CO_2) \cdot 2H_2O$, is described. It is similar to that of grossularite.

Determination of granular minerals. L. PERRUCHE. *Nature* [Paris], No. 3056, pp. 143–47 (1939).—P. describes a technical procedure used in the microscopic analysis of sedimentary, soft, or powdered minerals. R.W.D.

Formation and stability of muscovite in acid solutions at elevated temperatures. JOHN W. GRUNER. *Amer. Mineralogist*, **24** [10] 624–28 (1939).—Experiments show that the formation of muscovite or sericite does not occur in HCl solutions even in the presence of a large excess of KCl at temperatures around 300°C. At 400°C., muscovite will form in HCl solutions from aluminum hydroxide, silica, and KCl. Kaolinite will be converted to muscovite at this temperature in the presence of KCl. The presence of KCl will stabilize muscovite in HCl solutions at temperatures around 300°C. under conditions which do not permit its formation but which would ordinarily cause the formation of kaolinite. G. concludes, therefore, that in hydrothermal solutions the concentration of the K ions is of primary importance in connection with their reactions upon potash-bearing minerals. Lack of K ions will cause their decomposition. Above probably 350° to 375°C., pyrophyllite may form; below this temperature, kaolinite may form. The upper and lower temperature limits of these minerals are unknown at present. F.J.Z.

Granite pegmatites of the Mt. Antero region, Colorado. G. SWITZER. *Amer. Mineralogist*, **24** [12] 791–808 (1939). —The pegmatites have the typical magmatic minerals (microcline and quartz) and a variety of later hydrothermal minerals (beryl, phenacite, albite, bertrandite, and fluorite). The veins are equivalent to the hydrothermal phase of pegmatites. The upper temperature limit of formation of the pegmatites was approximately 600°C., as shown by frequent development of trigonal trapezohedron faces on smoky quartz crystals. The lower temperature limit of crystallization of the vein minerals was less than 200°C., as indicated by the position of adularia in the sequence of mineralization. A new angle table has been calculated for bertrandite. Twinned octahedra of fluorite are described. The relation between the structure and morphology of phenacite is pointed out and the crystallographic elements of phenacite are recalculated in a new preferred setting. F.J.Z.

Hydrothermal reaction of alkali solutions with kaolin: III. SHOICHIRO NAGAI AND TAMOTSU YAMADA. *Jour. Japan. Ceram. Assn.*, **46**, 77–83 (1938); *Chem. Abs.*, **32**, 4738 (1938).—Zettlitz kaolin heated in contact with 10% or 20% NaOH or KOH for 5 to 10 hr. on a water bath yielded 0.4 to $0.6R_2O \cdot Al_2O_3 \cdot 1.9$ to $2.1SiO_2 \cdot nH_2O$, while German kaolin yielded 0.8 to $0.9R_2O \cdot Al_2O_3 \cdot 2.7$ to 2.9 $SiO_2 \cdot nH_2O$. These results indicate incomplete reaction to nephelite hydrate under the conditions. The products lost part of their combined H_2O at 25° to 110° and all of it at 200° to 300°, whereas the kaolins lost their H_2O at 400° to 500°. Nephelite hydrate was also obtained on heating kaolin with Na_2CO_3 at 950° and extracting the excess alkali with hot H_2O. No reaction was observed between kaolin and 28% NH_3 solution after heating 1 to 3 hr. at 20 to 70 atm. pressure. For Part II see *Ceram. Abs.*, **18** [3] 83 (1939).

Indian pottery clays: II. M. P. BAJPAI. *Indian Ceramics*, **1** [3] 106–12 (1938).—B. surveys the known occurrence of pottery clays (other than fire clays) in the province of Bihar, India. Information regarding these is still meager although considerable preliminary work has been done on them. A ceramic survey of the province is recommended. The occurrence of large quantities of quartz and feldspar in the pegmatites of the Bihar mica belt, the occurrence of fire clays, kaolins, china clays, and other pottery clays in the various districts of Bihar, and large resources of coal place Bihar in a favorable position for the development of the pottery industry in India. **III.** M. L. MISRA. *Ibid.*, **2** [1] 31–33 (1939).—The occurrences of clays in the Central Provinces of India are briefly described. **IV.** M. L. MISRA AND M. B. YADAV. *Ibid.*, **2** [3] 103–106 (1939).—The ceramic raw materials available in Assam province, India, are briefly surveyed. It possesses huge deposits of fire clays, china clays, kaolins, and other pottery clays, and sillimanite, and corundum together with large reserves of coal and petroleum. So far only the coal and petroleum have been commercially exploited. A.P.S.

Kaolin-clay theory and its influence in the ceramic and geological fields. A. VASEL. *Zentr. Mineral. Geol.*, **1936A**, 290; *Trans. Ceram. Soc.*, **35** [11] 91A (1936).—

(*A*) *Ceramic:* Kaolins, clays, and allophanes are aluminum hydrosilicates and are termed by H. Harrassowitz "siallites" (Si-Al-lithos), in contradistinction to the allites, which consist mainly of hydrates of alumina. The new formula for clay is $2Al_2O_3 \cdot 4SiO_2 \cdot 3H_2O$, and that for kaolin is $6Al_2O_3 \cdot 12SiO_2 \cdot 9H_2O$. On heating the pure materials, the following changes occur:

$$\text{(Clay)}\ 2Al_2O_3 \cdot 4SiO_2 \cdot 3H_2O \rightarrow 2(Al_2O_3 \cdot 2SiO_2) + 3H_2O \quad (1)$$

$$\text{(Kaolin)}\ 6Al_2O_3 \cdot 12SiO_2 \cdot 9H_2O \rightarrow 2(3Al_2O_3 \cdot 2SiO_2) + 8SiO_2 + 9H_2O \quad (2)$$

The kaolin molecule is three times larger than the clay molecule. The degree of plasticity depends on the size of the molecule, so that plasticity increases in the series kaolin → clay → allophane. The porosity of kaolin fired at a temperature at which clays are already vitreous is due to the silica inclusions in the mullite (equation 2). (*B*) *Geological:* Siallite deposits either originate from the atmospheric weathering of aluminous rocks in tropical, humid climates or are due to the action of deep waters containing CO_2. The formation of the different siallites is explained by the composition of the original rock; kaolins are formed from potash feldspars, clays from soda feldspars, and allophanes from lime feldspars. The decomposition of the primary rocks leads directly to the different siallites and not to the separate oxides. See *Ceram. Abs.*, **15** [11] 345–46 (1936).

Land and sea movements in the Late Cretaceous of western Canada. Louis A. Russell. *Trans. Roy. Soc. Canada*, Sect. IV, pp. 81–99 (1939).—R. describes the spread and retreat of the seas during a period in which the Whitemud beds of southern Saskatchewan were forming. G.M.H.

Magnetic properties of ferric oxide at low temperatures. G. Charlesworth and F. A. Long. *Proc. Leeds Phil. Lit. Soc., Sci. Sect.*, **3**, 515–19 (1939).—The chemical estimation of ferric oxide in sand intended for glass manufacture is tedious. If ferric oxide behaved like a normal paramagnetic substance, its magnetic susceptibility would increase at low temperatures, as would that of sand containing it in proportion to its ferric oxide content. This would provide a method of estimation. The paramagnetic α form was used. The specific susceptibility at 20°C. was 37.5×10^{-6}. At about −28°C. a marked fall in the value occurred to about 18×10^{-6}. The temperature of change was higher (10°C.) on heating than on cooling. No change in crystal structure and no thermal effects were noticed at this temperature. The susceptibility of iron in glasses (unpublished) indicates that it is in the form of an ion, Fe^{+3}; the value is so much greater than that of iron in the oxide that the linkage in the latter cannot be ionic but is perhaps covalent or metallic. L.R.B.

Manganese deposits in the lower and middle Barama river of Northwest district, British Guiana. D. A. Bryn Davies. *Bull. Imperial Inst.*, **37** [2] 245–51 (1939).—D. describes several deposits of manganese ore including at least one believed to be of commercial importance. A much more extensive examination will be necessary before the quantity and grade of the ore available can be assessed. A.P.S.

Mysore's minerals and mineral industries. B. Rama Rao. *Chem. Trade Jour.*, **105**, 34 (1939).—Minerals won in Mysore, India, include chromite and magnesite, kaolin and fire clays (both of which are converted into firebrick), limestone and clays for cement manufacture, soapstones and china clays, graphite, quartz, feldspar, and asbestos. L.R.B.

Nepheline syenite. Editorial. *Indian Ceramics*, **1** [1] 25 (1938).—It is dubious if nepheline syenite can find employment in India as a partial substitute for soda in the glass and ceramic industries because, while as a raw material for glassmaking it has a slight advantage over feldspar (the ratio of alkali to silica is slightly higher), it introduces alumina into the glass to a large extent. Highly aluminous glasses have so far not been commercially used except for making cheap bottles. The technical difficulties involved in the manufacture render useless glass made with alumina as a major constituent. None of the pot furnaces existing in India gives a temperature suitable for the founding of aluminous glass. All aluminous raw materials can therefore find but little use in glassmaking in India. Nepheline syenite does not occur near any glass-producing center. It is usually contaminated with ferromagnesian minerals for which electromagnetic separation is necessary, involving not only extra cost but, unlike in the U. S., also heavy wastage in separation. A.P.S.

New method for the determination of feldspar twins. R. C. Emmons and R. M. Gates. *Amer. Mineralogist*, **24** [9] 577–89 (1939).—A new very rapid and accurate procedure for the determination of the twin laws is described. F.J.Z.

Polymorphism of the micas, with optical measurements. Sterling B. Hendricks and Merrill E. Jefferson. *Amer. Mineralogist*, **24** [12] 729–71 (1939). F.J.Z.

Possible occurrence and composition of a new kind of mineral substance in some clays. M. R. A. Iyer. *Records Mysore Geol. Dept.*, **36**, 108–77 (1938).—The material postulated has a composition similar to muscovite but has all silica replaced by alumina and contains a greater proportion of combined water. A.P.S.

Purification of china clay. S. C. Guha. *Indian Ceramics*, **2** [1] 41–43 (1939).—The Schwerin machines for electroosmosis of clay, the Schwerin electroosmotic filter press, and their operation are briefly described. A.P.S.

Random structures of layer minerals as illustrated by cronstedtite. Possible iron content of kaolin. Sterling B. Hendricks. *Amer. Mineralogist*, **24** [9] 529–39 (1939).—The mineral cronstedtite ($2FeO \cdot Fe_2O_3SiO_2 \cdot 2H_2O$) is formed of kaolin-like layers containing ferric ions with tetrahedral and octahedral coordination of surrounding oxygen and hydroxyl ions. These layers are superimposed with a random mixing of three possible structures which results in diffuse reflection along lines connecting $\{h_a\ k_a\ l\}$ reflections for which k_a is not a multiple of three. Although cronstedtite is related to kaolinite in structure it is improbable that the kaolinite lattice will accommodate appreciable amounts of iron in solid solution. The mineral faratsihite is shown to be a mixture of nontronite and an ordinary kaolin mineral. F.J.Z.

Reactions of solid substances at high temperatures: XX, Formation of anorthite and gehlenite by reaction in the solid state. Wilhelm Jander and Josef Petri. *Z. Elektrochem.*, **44**, 747–54 (1938); *Chem. Abs.*, **33**, 455 (1939).—Finely powdered mixtures of $CaCO_3$, Al_2O_3, and SiO_2 in correct proportions were heated at 1050° to 1100° for various periods of time. By X-ray studies (Debye-Scherrer) of compounds from these and various two-component systems similarly heated, proof of the formation of gehlenite, $2CaO \cdot Al_2O_3 \cdot SiO_2$, and of anorthite was obtained. The simpler systems gave evidence as to the intermediate compounds formed and the mechanism of the reactions; intermediates recognized were $12CaO \cdot 7Al_2O_3$, $CaO \cdot Al_2O_3$, β-$2CaO \cdot SiO_2$, $CaO \cdot SiO_2$, and gehlenite. For Part **XVIII** see *Ceram. Abs.*, **18** [8] 203 (1939); Part **XXI** see "Formation. . . .," *ibid.*, **19** [1] 30 (1940).

Recovery of titanium oxide as a by-product in the manufacture of alumina-ferric from bauxite. Sudhir Chandra Chakravarty. *Bull. Ind. Research Bur., Govt. of India*, No. 15, 22 pp. (1939).—C. describes a method of treatment whereby the waste product, mud, left as residue, can be made to yield titanium oxide. Bauxite, when used to manufacture alumina-ferric, leaves as residue a mud which contains 38% titanium oxide. C. shows that the mud can be made to yield titanium oxide 98 to 99% pure in sufficient quantities to make the recovery a profitable by-product of the alumina-ferric industry. The product is pure white in color. It can be used as a white pigment in the manufacture of paint and ceramics, as a component in vitrified enamels, and in the manufacture of soap. A.P.S.

Relation of crystal structure to base exchange and its bearing on base exchange in soils. W. P. Kelley and Hans Jenny. *Soil Sci.*, **41**, 367–82 (1936); *Chem. Abs.*, **30**, 6106 (1936).—The base-exchange capacities of a group

of silicate minerals were progressively increased many fold by dry grinding in a ball mill. Orthoclase (100-mesh) showed a base-exchange capacity of 5 milliequivalents per 100 gm. When ground for 24 hr. the capacity was increased to 22, for 48 hr. to 42, and for 120 hr. to 91.5. Other members of the feldspar group showed proportionate increases on grinding. Minerals such as kaolinite and pyrophyllite showed high base-exchange capacity when ground for several days. Quartz and bauxite showed negligible base exchange after grinding. Cecil soil colloid of 1 μ size limit had 17 milliequivalents base-exchange capacity. After 48 hr. grinding this was increased to 151. Grinding changed the pH value from 7.2 to 5.4. Diagrammatic representation is made of a Si-O layer of a clay crystal with cations attached to the free O valences. With the exception of bases that have replaced H ions from broken lattices of the hydrous minerals, only those metallic cations which perform the function of balancing the excess negative charges of the tetrahedral groups are reversibly replaceable by NH_4. When kaolinite and pyrophyllite are finely ground, relatively many OH ions of the lattice become exposed, because breaks are produced, either across the octahedral layers or parallel thereto. It is thought that the OH of the lattice of clay minerals is an important source of their potential cation exchange power. It does not follow, however, that the OH group is the sole cause of their exchange power.

Residual alaskite kaolin deposits of North Carolina. CHARLES E. HUNTER. *Bull. Amer. Ceram. Soc.*, **19** [3] 98–103 (1940).

Shortite, a new carbonate of sodium and calcium. JOSEPH J. FAHEY. *Amer. Mineralogist*, **24** [8] 514–18 (1939).—F. studied crystals found in cores of clay shale from Sweetwater County, Wyoming, at depths between 1250 and 1805 ft. Analyses of two types of crystals give the formula $Na_2O \cdot 2CaO \cdot 3CO_2$. F.J.Z.

Singhbhum chrome ore. M. V. WAZALWAR. *Tisco Rev.* [India], **6** [2] 86–88 (1938).—The chromite occurs in ultrabasic rocks as sheets dipping at various angles, as pockets and disseminations, and as veins in adjacent country. The average ore contains 47 to 50% Cr_2O_3 and 18 to 20% FeO. A.P.S.

Sorption of water vapor by vermiculite and its silica. L. A. HANSON, W. S. SAMUEL, JR., AND P. A. FORNI. *Ind. Eng. Chem.*, **32** [1] 116–18 (1940).—Illustrated. F.G.H.

South African chrome ores. ANON. *Chem. Trade Jour.*, **105**, 72 (1939).—Chrome ore for chrome brick, according to the experience of S. African suppliers, should have a Cr_2O_3 content of 40 to 43%. The iron content is of the utmost importance, some British buyers of chrome insisting on a guarantee of 14% maximum FeO and 5% maximum silica. For German buyers the permissible FeO maximum is generally 17%; French buyers call for a maximum of 16%. L.R.B.

Status of Fukushu clays in Manchuria. TAKEHITO SHIBATA. *Jour. Japan. Ceram. Assn.*, **47** [555] 141–45 (1939).—The present condition of Fukushu clays is described. They are produced at Gokoshi in Fukuken of Hotensho. They construct the F stratum of four common clays and the G stratum of five hard clays. The refractoriness of the common clays varies from cone 34 to 35. They are decidedly plastic. The chemical composition and P.C.E. of the hard clays are as follows:

	Alumina (%)	Silica (%)	Cone
Common hard clay	45	35	35
Superior hard clay	Over 60	Below 20	37
Special hard clay	Over 70	Below 10	38

The present annual mining capacity is about 400,000 tons. S.K.

Summary of occurrence, properties, and uses of vermiculite at Libby, Montana. W. WURTH KRIEGEL. *Bull. Amer. Ceram. Soc.*, **19** [3] 94–97 (1940).

Zeolites. V. CHARRIN. *Ind. Chim.*, **26** [305] 376–77 (1939).—Natural zeolites are considered. R.W.D.

BOOKS AND SEPARATE PUBLICATION

Available Raw Materials for a Pacific Coast Iron and Steel Industry: Vol. I, Summary; Vol. II, Detailed Data Relating to Markets and Economic Setting; Vol. III, Detailed Data Relating to Local Domestic and Foreign Iron Ore Supplies; Vol. IV, Detailed Data Relating to Reducing Agents, Fluxes, and Refractories. Edited by EDWIN T. HODGE. North Pacific Division, Portland, Oregon, 1935. Vol. I, 180 pp., 29 plates; Vol. II, 155 pp.; Vol. III, 290 pp.; Vol. IV, 285 pp. Price $1.25 per vol. Reviewed in *Ind. Eng. Chem., News Ed.*, **14** [2] 28 (1936).—Refractories requirements are thoroughly discussed in Vol. IV. F.G.H.

Minerals, Metals, and Gems. A. HYATT VERRILL. Page Co. 293 pp. Price $3.00. Reviewed in *Science News Letter*, **36** [18] 288 (1939).—V. presents facts about the mineral kingdom. P.G.H.

Precious and Semi-Precious Stones. MICHAEL WEINSTEIN. Pitman Publishing Corp., New York. 192 pp. Price $3.00. Reviewed in *Science News Letter*, **36** [25] 400 (1939).—Much information on the mining and working of the stones is given as well as descriptions of the gems themselves. P.G.H.

Study of Materials in Suspension, Mississippi River. *U. S. Waterways Expt. Sta., Miss. River Commission* (Vicksburg, Miss.), *Tech. Memorandum*, No. 122–1, 27 pp., 11 tables, 83 plates (1939); reviewed in *Jour. Sed. Petrology*, **9** [3] 134–35 (1939). G.M.H.

PATENT

Activation of clays. W. S. WILSON (Monsanto Chemical Co.). U. S. 2,192,000, Feb. 27, 1940 (Dec. 19, 1936).

Chemistry and Physics

Analysis of chromium oxide. N. I. ROBIONOVA. *Zavodskaya Lab.*, **6**, 630–31 (1937); *Brit. Chem. Abs.–B*, **56**, 1199 (1937).—Cr_2O_3 (0.5 gm.) is dissolved in a boiling solution of 1.5 gm. of $KBrO_3$ in 10 ml. of H_2O; the solution is evaporated with 7 ml. of H_2SO_4, diluted to 100 ml., and filtered; the washed residue is ignited and weighed as SiO_2. The filtrate and washings are diluted to 250 ml., and 40 ml. of 25% H_2SO_4, 15 ml. of 1% $AgNO_3$, 0.01 gm. of $MnSO_4$, 20 ml. of 15% $(NH_4)_2S_2O_8$, and H_2O to 250 ml. are added to 100 ml. of solution, which is boiled until a red coloration (MnO_4') develops, when 2 gm. of NaCl are added, and boiling is continued for 10 min. after decoloration. Standard $FeSO_4$ is then added, excess of which is titrated with $KMnO_4$. Sesquioxides and Ca are determined in separate portions of the filtrate.

Clays: IV–V. MUNE UTIDA. *Jour. Japan. Ceram. Assn.*, **47** [553] 27–33 (1939).—The thermal dehydration of Kochite, Otoge pyrophyllite, acid clays (fuller's earth), bentonites, zeolites, a diaspore, and a bauxite is reported, and their origin, chemical composition, and physical properties are discussed. **VI–VII.** *Ibid.*, [554] 89–94.—Thermal-dehydration curves are given for the binary systems kaolin–bentonite, silica gel–bentonite, silica gel–pyrophyllite, and bentonite–pyrophyllite. Progress in the concept of clay substance and the classification of clay minerals is discussed. The classification of clay minerals based on lattice construction is described. S.K.

Colloid constituents of California soils. W. P. KELLEY, W. H. DORE, A. O. WOODFORD, AND S. M. BROWN. *Soil Sci.*, **48** [3] 201–55 (1939).—The colloids of the Yolo and San Joaquin family of soils contained substantial amounts of nonexchangeable magnesium. Base-exchange capacity, however, is not proportional to the Mg content. The SiO_2 to Al_2O_3 ratio varied from 4 to 2. Although there is a rough proportionality between the SiO_2 to Al_2O_3 ratio and base-exchange capacity, the correlation is not high. The

dehydration curves are characteristic of each type of colloid, the shape of the curve depending largely on the kinds and relative proportions of the different clay minerals present. A relatively good correlation was found between water loss at 100° and 150°C. and base-exchange capacity. Optical properties showed that these colloids were preponderantly crystalline. Saturation with Ca, Mg, K, and Na appeared to have but little influence on their optical properties. The optical properties, while less diagnostic, are consistent with the conclusions from X-ray study. G.R.S.

Crystal structure of aluminum metaphosphate. LINUS PAULING AND J. SHERMAN. *Z. Krist.*, **96**, 481–87 (1937) (in English); *Chem. Abs.*, **31**, 8296 (1937).—The unit cube of $Al(PO_3)_3$ has $a = 13.63$ a.u. and contains 16 mol. with space group $T_d^6 - I\bar{4}3d$. On the basis of certain assumptions regarding the coordination polyhedra, a structure is formulated with Al in 16*c*, $u = 0.117$; *P* in 48*e*, $x = 0.340$, $y = 0.073$, $z = 0.124$; O_I in 48*e*, $x = 0.090$, $y = 0.110$, $z = 0.800$; O_{II} in 48*e*, $x = 0.095$, $y = 0.141$, $z = 0.245$; O_{III} in 48*e*, $x = 0.137$, $y = 0.096$, $z = 0.986$. The crystal contains complexes P_4O_{12} consisting of four PO_4 tetrahedra with P–O = 1.51 a.u., each of which shares two corners with other tetrahedra and the other two corners with AlO_6 octahedra. Each AlO_6 octrahedron (with Al–O = 1.83 a.u.) shares its six corners with six P_4O_{12} complexes. This metaphosphate group is closely similar to the metasilicate group in various metasilicates.

Determination of pH. P. BREMOND. *Arts du Feu*, **2** [12] 181–86 (1939).—B. describes a practical method for determining the pH of plastic bodies and ceramic slips. The importance of pH in ceramic manipulation is emphasized. Practical examples in the ceramic field are given. F.E.V.

Diatomaceous earths of the Noto Peninsula: I, Occurrence and quality. MASAMI ÔNO AND SEIJI KONDO. *Jour. Japan. Ceram. Assn.*, **47** [553] 3–7 (1939).—The occurrence of the diatomaceous earths of the Noto Peninsula is explained. Diatomaceous earth produced near the Wakura hot spring is of a superior type; it analyzes as follows: loss on ignition 10.22, silica 74.28, alumina 11.79, ferric oxide 1.59, lime 0.56, magnesia 0.82, and total 99.26%. It is used raw for the manufacture of insulating brick or calcined like the celite of California. S.K.

Direct-current resistance of ceramic materials. H. RÖGENER. *Z. Elektrochem.*, **46** [1] 25–27 (1940).—R. gives data on the d.-c. resistance of Al_2O_3, BeO, ZrO_2, ThO_2, and spinel. Plotted on a graph with $\frac{1}{T \text{ abs.}}$ as abscissa and $\frac{1}{\text{ohm/cm.}}$ in log scale as ordinate, the change of resistance follows straight lines, the end points of which are as follows:

	Ohm/cm.	°C.	Ohm/cm.	°C.
Al_2O_3	1×10^8	830	1×10^6	1095
BeO	3.85×10^8	630	5.2×10^6	1100
ZrO_2	2.1×10^8	340	2.3×10^4	700
ThO_2	2.6×10^7	550	3.85×10^4	950
Spinel	4.8×10^7	470	2.0×10^5	1100

Changes due to pretreatment and impurities are mentioned, and the fact that the data vary according to these conditions is stressed. The experimental setup is described. J.M.N.

Electrodialysis of soils: IV, Effect of temperature, pH value, and degree of alkalization. A. N. PURI, R. C. HOON, AND C. L. DHAWAN. *Soil Sci.*, **47** [6] 479–85 (1939).—The electrodialysis of soils at different pH values and varying degrees of alkalization was studied. The rate of electrodialysis increases with the increase in pH value. The variation in the ratio Ca/Na in the electrodialyzate of alkali soils is caused by the deficiency of available Ca. The rate of electrodialysis reaches a maximum at about 30°C., but the effect of temperature on the whole is slight. For Part III see *Ceram. Abs.*, **17** [8] 291 (1938). G.R.S.

Geology and soil valuation of the Black Forest. SCHNARRENBERGER. *Ber. Deut. Keram. Ges.*, **19** [7] 245–54 (1938).—S. discusses the geological formations and minerals found in the Black Forest, with special emphasis on ceramic raw materials. E.J.V.

Glass state and transformation point. PAUL LAGALLY. *Umschau*, **44** [7] 97–99 (1940). J.M.N.

Heat of formation of Cr_2O_3. W. A. ROTH AND URSULA WOLF. *Z. Elektrochem.*, **46** [1] 45–46 (1940).—Recent experiments resulted in the following heats of formation: $Cr_2O_3 = 268.9 \pm 0.6$ Cal. and $CrO_3 = 137.1 \pm 0.4$ Cal. at 21°C. and constant pressure. J.M.N.

Heats of formation of Al_2O_3 and La_2O_3. W. A. ROTH, URSULA WOLF, AND OLGA FRITZ. *Z. Elektrochem.*, **46** [1] 42–45 (1940).—Recent experiments resulted in the following heats of formation: $Al_2O_3 = 402.9 \pm 0.3$, $Al_4C_3 = 50 \pm 3$, and $La_2O_3 = 539 \pm 4$ Cal. at 22°C. and constant pressure. J.M.N.

Investigations of cobalt and the system cobalt–carbon. WILHELM F. MEYER. *Z. Krist.*, **97**, 145–69 (1937); *Chem. Abs.*, **31**, 8339 (1937).—X-ray photographs at temperatures up to 1100° show no second transformation of Co. On heating with illuminating gas up to 230° to 270°, a mixed crystal of variable composition is formed, which is unstable at room temperature. At 500° to 800° stable Co_3C is formed, analogous to Fe_3C. Its unit cell dimensions are $a = 4.52$, $b = 5.08$, $c = 6.73$ a.u. Heating with benzene and CO also produces Co_3C.

Iodometric determination of alkali. G. STANLEY SMITH. *Analyst*, **62**, 590–96 (1937); *Chem. Abs.*, **31**, 6994 (1937).—Walker and Gillespie improved the iodometric determination of alkali by introducing an excess of 0.1 *N* I solution, boiling gently until excess I_2 was expelled, cooling, adding acid, and titrating the liberated I_2, which is equivalent to the I_2 originally reacting with OH^-, with $Na_2S_2O_3$ to a starch end point. The presence of carbonate, however, caused trouble. If a liberal excess of I_2 is used and the reaction is allowed to proceed sufficiently long at the boiling temperature, all the alkali of carbonates, bicarbonates, $BaCO_3$, $CaCO_3$, and Na silicate and aluminate can be converted into iodate. To the sample in 50 ml. of water, add 2 to 3 ml. of pure benzene and an excess of sublimed I_2. Heat in a 150- to 250-ml. flask with reflux cooling until the reaction is judged to be complete. With dried pure $BaCO_3$ it was necessary to reflux for more than 9 hr., but with $Ba(OH)_2$ solution saturated with CO_2 3 hr. was sufficient. After the oxidation to iodate is complete, remove the water from the condenser (which is attached to the flask by a ground-glass joint) and carefully boil off all excess I_2. Cool, make acid with H_2SO_4, and titrate with $Na_2S_2O_3$ solution. The results were low with solid alkaline-earth carbonate and with borax.

Microchemistry of rare earths. G. BECK. *Mikrochemie*, **27** [1–2] 47–51 (1939).—The rare earths and zirconium compounds yield violet solutions with a tincture of cochineal; thorium salts give blue solutions. The violet solutions of the cerite earths from lanthanum to samarium become reddish orange on the addition of dilute acetic acid, the original color of the cochineal tincture being restored. With terbium and erbium earths and zirconium, strong acetic acid is necessary to change the color to red, and a change in the original reddish orange results only when quite concentrated acetic acid is used. L.E.T.

Micromethods for the determination of calcium and phosphate. R. S. MANLY. *Mikrochemie*, **27** [3] 146–53 (1939).—Tables are presented showing 75 different methods for the determination of calcium and phosphate. The weight of the constituent determined, special reagents and apparatus, principles, use, accuracy, and precision are given. The purpose of this compilation is to provide a ready reference list for workers planning to initiate routine analyses for substances for which standard methods have not been developed. 78 references. L.E.T.

Modulus of elasticity and spalling: I. SHIN-ICHI SUZUKI. *Jour. Japan. Ceram. Assn.*, **47** [557] 230–33 (1939).—The difficulties in the determination of the modulus of elasticity are theoretically explained and dis-

cussed. S. points out that plastic deformation is closely related to the modulus. S.K.

Pegmatites of the Spruce Pine district, North Carolina: I. C. S. MAURICE. *Econ. Geol.*, **35** [1] 49–78 (1940).—M. investigated 180 pegmatites in the field and determined the plagioclase for more than 100 of them. Plagioclase predominates over the microcline and crystallized first. The amount of microcline varies with the composition of the plagioclase. Minor amounts of albite are metasomatic replacements. Much of the commercial mica is primary. Accessory minerals include compounds of columbium, uranium, rare earths, allanite, beryl, etc., 11 figures. J.L.G.

Physicochemical reactions between organic and inorganic soil colloids as related to aggregate formation. H. E. MYERS. *Soil Sci.*, **44**, 331–59 (1937); *Chem. Abs.*, **32**, 1029 (1938).—M. studied the influence of various organic colloids upon the properties of soil colloids extracted from Putnam, Hayes, and Davidson soils and a bentonite colloid. The organic colloids were obtained from NH_4OH extracts of composts of straw, corn stover, and alfalfa. Organic colloidal solutions altered the viscosity of colloidal clay to a greater extent than could be explained by mechanical mixing. The alteration in viscosity was influenced by the quantity of organic colloid added, the kind of cation present, and the type of soil colloid used. A reduction in base-exchange capacity resulted when organic colloids were mixed with soil colloids or with finely divided quartz or other mineral. The magnitude of the reduction resulting from mixing varied from 6 milliequivalents per 100 gm. of colloid when straw and Al_2O_3 were mixed to as much as 65 when straw and Davidson colloid were the constituents. With increasing quantities of organic colloid, the migration velocities increased to a maximum and then decreased. There is some evidence of a chemical union between the organic and the inorganic colloids. In general, this tendency to combine is most marked under acid conditions. The exchange capacity of organic colloids is not greatly influenced by desiccation when the material is thoroughly rewetted. The synthesis of aggregates was measured by determining the percentage of material in aggregates larger than 0.1 mm. Organic colloids saturated with either Ca or H ions were much more effective in cementing sand particles into water-stable aggregates than were the corresponding inorganic systems. Dehydration was necessary for the formation of stable aggregates. The favorable effect of organic matter on aggregation was probably associated with a low degree of dispersion after dehydration. Desiccated Ca organic colloid was more easily reversible in water than was the corresponding H colloid.

Preparation of kaolin and clay. G. GERTH. *Ber. Deut. Keram. Ges.*, **19** [12] 513–28 (1938).—G. discusses the various processes of purifying, classifying, and improving kaolins and clays, such as oil flotation, centrifuging, and settling processes. E.J.V.

Properties of soils from North American arctic regions. I. C. FUESTEL, A. DUTILLY, AND M. S. ANDERSON. *Soil Sci.*, **48** [3] 183–99 (1939).—Mechanical analysis showed that a large part of the material consisted of particles in the coarser size groups. The clay content was generally small, only three samples having as much as approximately 20% and a majority of the 34 remaining samples having less than 5%. Examination of the colloids extracted from a group of the mineral soils showed silica-base ratios of 5.5 or lower and accompanying SiO_2-Al_2O_3 ratios of 3.0 to 3.7. These and other factors are indicative of their extreme immaturity or of only a slight chemical alteration. Hydrous mica was shown by X-ray and heating curves to be the dominant clay mineral. G.R.S.

Raw materials of refractories: I. TAKEO AO. *Jour. Japan. Ceram. Assn.*, **47** [559] 351–55 (1939).—The mineralogical and chemical composition, refractoriness, and specific gravity of Roseki clay or agalmatolite are discussed. A. classifies the clay, according to its quality, into the following three grades: (1) the higher grade or diaspore-agalmatolite, consisting of diaspore and a small proportion of kaolinite; (2) the medium grade or kaolinite-agalmatolite, a mixture of kaolinite and pyrophyllite; and (3) the lower grade or pyrophyllite-agalmatolite, composed of pyrophyllite and accessory minerals such as quartz, sericite, alunite, etc. S.K.

Stability of peroxidized titanium solutions. GILBERT H. AYRES AND EDMAY M. VIENNEAU. *Ind. Eng. Chem., Anal. Ed.*, **12** [2] 96 (1940).—The yellow color of titanium in an acid solution of hydrogen peroxide is entirely stable, and the use of artificial standards for the purpose of obtaining stability is unnecessary. F.G.H.

Theoretical formula for the solubility of gases in metals. R. H. FOWLER AND C. J. SMITHELLS. *Proc. Roy. Soc.* [London], **A160** [900] 37–47 (1937); *Bull. Brit. Non-Ferrous Metals Research Assn.*, No. 99, p. 17 (June, 1937).—A mathematical discussion is presented.

Yamagata bentonite and its origin: VII, Relation between bentonite and acid clay. MUNE UTIDA. *Jour. Japan. Ceram. Assn.*, **47** [554] 63–67 (1939).—On the basis of many analytical data, U. concludes that bentonite and acid clay or fuller's earth are the same clayey substance, and they must contain at least montmorillonite and beidellite as two common principal minerals. Bentonite and the so-called acid clay are, therefore, nothing but rock names. The average compositions of Japanese acid clays and Manchurian bentonite are as follows:

	H_2O	SiO_2	Al_2O_3	Fe_2O_3	CaO	MgO	Na_2O	K_2O
Acid clay (mol.)	2.5	8.0	1.00	0.15	0.15	0.35		0.10
Acid clay (%)	6.5	71.0	15.00	0.5	1.0	2.0		1.0
Bentonite (mol.)	2.97	4.98	1.00	0.17	0.13	0.16	0.23	0.16
Bentonite (%)	10.48	58.48	19.99	5.39	1.48	1.23	2.84	2.89

For Part IV see *Ceram. Abs.*, **18** [3] 85 (1939). S.K.

BOOK

Handbook of Chemistry and Physics. Edited by CHARLES D. HODGMAN. Chemical Rubber Pub. 23d ed. 2221 pp. Price $3.50. Reviewed in *Science News Letter*, **36** [12] 192 (1939).—Additions and revisions include a melting and boiling point index of organic compounds, ionization potentials, potentials of electrochemical reactions, the elements, isotopes, definitions of chemical terms, and composition and value of foods. P.G.H.

PATENTS

Amorphous silica. R. V. HEUSER (American Cyanamid Co.). Can. 385,723, Dec. 19, 1939 (Oct. 16, 1936; in U. S. Nov. 1, 1935). G.M.H.

Obtaining beryllium and beryllium alloys. CARLO ADAMOLI (Perosa Corp.). U. S. 2,193,363, March 12, 1940 (May 24, 1937). U. S. 2,193,364, March 12, 1940 (April 17, 1939).

Producing white titanium dioxide pigments of predetermined subordinate tints. R. M. MCKINNEY (E. I. du Pont de Nemours & Co.). U. S. 2,192,501, March 5, 1940 (March 20, 1936).—A process for controlling the subordinate tint of a precipitated, calcined titanium oxide pigment comprises cooling the pigment in the presence of an oxygen-containing gas, after calcination at a temperature in excess of substantially 900°C., to a temperature of substantially 750°C. and, to obtain a pigment of desired bluish tint, effecting the cooling within a period of about 3 to 5 sec. or, to obtain a product of desired yellowish tint, effecting the cooling over a period of at least 5 min. but not to exceed about $7\frac{1}{2}$ min.

Production of composite titanium pigments. E. I. DU PONT DE NEMOURS & CO. Brit. 517,913, Feb. 28, 1940 (May 27, 1937).

Production of rutile pigments. J. L. KEATS (E. I. du Pont de Nemours & Co.). U. S. 2,193,559, March 12, 1940 (March 10, 1939).—A cyclic process for producing a rutile pigment comprises digesting a titanium oxide-containing material with barium hydrate, adding nitric acid to the resulting barium titanate thereby forming barium nitrate and titanium nitrate, separating the barium nitrate from the titanium nitrate solution, hydrolyzing the titanium nitrate and separating the rutile precipitate from the acid solution, decomposing the aforementioned separated barium nitrate to produce oxides of nitrogen and barium, and thereafter employing the oxides to produce nitric acid and barium hydroxide for reuse in the aforementioned process.

Production of titanium dioxide pigments. BRITISH TITAN PRODUCTS CO., LTD. Brit. 517,742, Feb. 21, 1940 (Aug. 7, 1937).

Rutile pigment from barium titanate. R. M. MCKINNEY (E. I. du Pont de Nemours & Co.). U. S. 2,193,563, March 12, 1940 (March 10, 1939).

General

Aerosols—dust, smoke, fog, clouds, and air pollution as problems relating science, economics, and health. H. W. LOHSE. *Can. Chem. Met.*, **21**, 340–42 (1937); *Chem. Abs.*, **32**, 263 (1938).—Aerosols are systems consisting of finely divided matter (solid or fluid), dispersed and suspended in a gaseous medium. They are characterized by their instability. Coagulation and precipitation methods are discussed as well as air pollution and smoke abatement.

Ceramic education. EMERSON P. POSTE. *Enamelist*, **17** [1] 4, 41–43 (1939).—P. discusses present problems of ceramic education. Engineering education should include training in science, mathematics, economics, and sociology rather than mere specialized professional training or selected courses in technology. L.E.T.

Collection and separation of dust: I. JUNICHI ISOBE. *Jour. Japan. Ceram. Assn.*, **47** [553] 17–19 (1939).—The motion of particles in and falling through horizontal steady flow is mathematically treated, and new equations are proposed. **II.** *Ibid.*, [556] 196–200.—The loci of the motion of particles represented by the equations are graphically explained, and the necessary conditions for dust collecting or separating apparatus utilizing such a motion are pointed out. The efficiency of a dust chamber or separator depends mainly on the height and length of the chamber and on the velocity of the fluid. A dust chamber must be built as low and as long as possible, while a separator must be built adequately high and short. This theory was roughly proved by an experiment on the dust setting of rotary kiln gases. In a small dust chamber 1.8 x 1.8 x 6 m., about 27 kgm. of dust were deposited from the gases in 2 hr.; when the chamber was divided by partition walls into shallow chambers 40 cm. and 20 cm. high, about 36 and 110 kgm., respectively, were collected in 2 hr. S.K.

Detection of early lead injury by observing the skin vessels. H. OTTO AND G. HAHN. *Z. Klin. Med.*, **136**, 61–76 (1939).—Using the capillary microscope, the spasmodic effect of lead was demonstrated in the capillaries and arterioles. The observations are of the utmost importance in the study of the pathology of lead poisoning (high blood pressure, kidney disease) since it is the authors' opinion that the capillary changes are irreversible and gradually pass over into an arteriocapillary fibrosis. F.S.M.

Executive and the technologist. WILLIAM B. BELL. *Ind. Eng. Chem., News Ed.*, **18** [5] 185–90 (1940). E. C. WILLIAMS. *Ibid.*, pp. 191–94. F.G.H.

Experimental study on ingestion of lead compounds. R. A. KEHOE. *Jour. Amer. Med. Assn.*, **114**, 438 (Feb. 3, 1940).—Two human subjects were used: one ingested 2 mgm. of soluble lead daily for six months, and the other ingested 1 mgm. for a period of 30 months. Neither had any symptoms of plumbism, even of the vague type, and they did not show any of the blood changes. The results are highly significant in connection with the hygienic problem of human lead ingestion with food and beverages and in relation to the diagnosis of lead intoxication. F.S.M.

Free and combined silica in silicotic lungs. G. E. AND M. J. YOUNGBERG. *Proc. Soc. Exptl. Biol. & Med.*, **43**, 146–48 (Jan., 1940).—Data and results on 14 silicotic lungs obtained from autopsies are given. Free silica varies greatly, both in actual concentration and in the per cent of total silica; concentrations range from 0.086% to 1.296% of the dry lung; as a part of the total silica, the free silica ranges from 3.25% to 91%. The total silica was determined by the gravimetric hydrofluoric acid method. F.S.M.

Gastrointestinal diseases among steel workers. F. E. H. DAY. *Can. Pub. Health Jour.*, **30**, 555 (Nov., 1939).—The importance of this problem is demonstrated by the fact that, during 1938, a steel plant employing 3200 workers had 2377 days of lost time due to gastrointestinal disease in contrast with 946 days lost for respiratory illnesses and 881 days lost for cardiovascular diseases. The changing weekly shift is undoubtedly an important factor in the prevalence of gastric and intestinal disorders. There were no peptic ulcers, as far as is known, among 75 women employees (office workers), but there were 80 men with positive X-ray diagnoses of ulcer and one death from a perforation. D. believes that this figure is extremely low, as post-mortem observations show scars of ulcers in about 10% of the cases. He wonders what influence a regulated mid-shift meal would have on the incidence of these conditions. F.S.M.

Leon J. Houze, Sr., 1857–1940. ANON. *Bull. Amer. Ceram. Soc.*, **19** [3] 104–105 (1940).

Industrial hernia and its control. L. H. FRECHTLING. *Nat. Safety News*, **41**, 34 (Jan., 1940).—Hernias may be divided into two types with regard to etiology: traumatic and occupational. The first type is relatively rare, including those produced by violence and by weakness of the abdominal wall. The common or industrial type far outnumbers the others. It is said that in this country one person in every thirty has a hernia. It has been estimated that an individual with a hernia is good for only 25% of his possible efficiency. Physical examination, personal history, presence of tuberculosis, diabetes, or syphilis, and proper placement of the worker are all important factors in the prevention of hernia. In F.'s opinion, control by mechanical means should be considered as only a temporary measure. The problem of hernia in compensation cases is discussed. F.S.M.

Industrial hygiene for the smaller plants. GLENN S. EVERTS. *Amer. Jour. Pub. Health*, **30** [1] 17–21 (1940).—In addition to the common industrial hazards of fumes, dusts, etc., many lesser but likewise important hazards involving working conditions were found to exist in a survey made of 26 plants. These can be best detected and corrected through a careful study of operating conditions and processes and by cooperation with a local practitioner who has interested himself in industrial hygiene. B.C.R.

Industrial research in 1939. Advances in the U. S. and other countries. WILLIAM A. HAMOR. *Ind. Eng. Chem., News Ed.*, **18** [1] 1–13; [2] 49–58 (1940).—Developments in mineral and glass technology and other ceramic fields are thoroughly reviewed. Illustrated. F.G.H.

Industrial siliceous dust. H. VIGNERON. *Nature* [Paris], No. 3045, p. 167 (1939). R.W.D.

Lead content of urine and its relation to clinical diagnosis of lead poisoning. J. F. REITH AND C. P. VAN DIJK. *Nederland. Tijdschr. Geneeskunde*, **83**, 1584–91 (1939).—The normal ingestion of lead is estimated to be 250 to 500 μgm. per day and is mostly eliminated in the feces. Although the urinary elimination of lead is regarded as the best indicator of the severity of lead poisoning, there is a lack of agreement on the normal lead content of the urine.

The authors studied the urine of 102 normal persons. Using the dithizone method, they found that in 98% of the cases the value for lead was below 50 μgm. Bismuth is a possible source of error as it reacts almost like lead with diphenylthiocarbazol. F.S.M.

Lead poisoning and Parkinsonism. ANON. *Jour. Amer. Med. Assn., Queries & Minor Notes*, **114**, 79 (Jan. 6, 1940).—There is no known relationship between lead poisoning and the Parkinson syndrome. Although chronic lead poisoning causes a severe encephalopathy, no cases of Parkinsonism have been described. Manganese is one of the metals known to cause a Parkinsonian-like state. F.S.M.

Origin of silicosis claims. ANON. *Ohio Industrial Commission Monitor*, **13**, 16 (Jan., 1940).—The Silicosis Amendment to the Occupational Disease Act of Ohio became effective July 31, 1937. An analysis shows that, of the 330 silicosis claims since then, 111 were allowed, 165 were disallowed, and 54 are still pending. A study of their source reveals that 59 cases or 53.1% originated in foundries: 14 in steel, 32 in iron, and 13 in nonferrous plants. Forty-two or 37.9% were in the ceramic industries and were distributed as follows: building brick and tile 1, enamels 2, firebrick 1, floor and wall tile 8, glasshouse refractories 8, insulating brick 3, insulators 1, silica sand and diatomaceous earth 2, stoneware products 2, and tableware 14. Eight or 7.2% were in cut stone plants, 6 in monument works, and 1 each in quarries and building stone. There was one case in the polishing and buffing of iron and steel and one in the grinding of knives on a sandstone wheel. F.S.M.

Patent litigation in 1939. NELSON LITTELL. *Ind. Eng. Chem., News Ed.*, **18** [3] 97–101 (1940).—Significant decisions and trends in patent law are reviewed. F.G.H.

Progress reports from the Electrotechnical Laboratory, Bureau of Mines, at Norris, Tennessee. HEWITT WILSON, M. S. NELSON, AND STAFF. *Bull. Amer. Ceram. Soc.*, **19** [3] 92–94 (1940).

Reports of Committees and Resolutions. Sixth National Conference on Labor Legislation. ANON. *U. S. Dept. Labor, Div. Labor Standards, Bull.*, No. 35A (1939).—The committee which reviewed the recommendations of earlier conferences dealing with industrial health, safety, and workmen's compensation reaffirmed the need for compulsory compensation laws covering occupational injuries of all types including diseases, insurance in an exclusive state fund, coverage of all industries and all employers regardless of size of establishment, and informal and nontechnical procedures. New items added by the committee and from the floor included recommendations that medical boards should not have the final say on occupational-disease claims; that the management and personnel of state funds should be nonpolitical; and that, where workmen's compensation is administered outside of the agency making factory inspections, the two agencies should exchange information gathered by each. The Secretary of Labor was requested to appoint a committee to inquire into and report to next year's conference upon pre-employment physical examinations. An amendment to Senator Wagner's Health Program Bill was asked for the purpose of making funds available to state labor departments (on an equal basis with state departments of health) for the promotion and control of industrial hygiene. F.S.M.

Silicosis and the analyst. F. S. FOWWEATHER. *Analyst*, **64** [764] 779–87 (1939).—F. discusses the problem of silicosis as related to the various industries. In studying the relation between the silica content of the lungs and the degree of silicotic fibrosis, no definite correlation could be found, although, in general, the more fibrotic portion of the lung has been found to contain more silica than the less fibrotic portion. Great differences in the degree of fibrosis were found where differences in the silica content were relatively small and vice versa. In the great majority of cases, the analyst can be of little assistance in proving the presence or absence of silicosis. B.C.R.

Small foundry's health program. P. E. RENTSCHLER. *Nat. Safety News*, **40**, 82 (Oct., 1939).—R. describes experience in a system of physical examination, X-rays, and serology of a small industrial plant. A program of education insured full cooperation and interest on the part of the employees. So much enthusiasm developed that the families of employees were brought into the meetings for health education. F.S.M.

Statistical research on the frequency of gastric ulcers under different occupational conditions. R. DUESBERG AND W. WEISS. *Arbeitsschutz*, **1939**, pp. 272–73.—A previous publication by D. showed that pyloric ulcer is more common in men who do strenuous work and do not have an adequate mid-day lunch period. A statistical analysis of this material now reveals that among these workmen, the percentage of gastric ulcers is 2.5% as compared with 0.3% among clerks and officials. F.S.M.

BOOKS

Fifty Years in Engineering. EMBURY A. HITCHCOCK in collaboration with MERRILL WEED. Caxton. 277 pp. Price $3.00. Reviewed in *Science News Letter*, **36** [15] 240 (1939).—H. gives a cross section of a half century of engineering progress. P.G.H.

Lead poisoning and carbon monoxide poisoning cases settled, 1933–1938. ANON. *Workmen's Compensation Statistics, Industrial Commission of Wisconsin*, Dec. 15, 1939.—For the six year period 1933–1938, a table shows 74 cases of industrial lead poisoning which cost $57,093 or an average of $772 per case for indemnity and medical aid benefits. It also shows 131 cases of industrial carbon monoxide poisoning which cost $35,682 or an average of $272 per case. A majority of the lead poisoning cases was due to the absorption of lead from ordinary commercial paints. Most of the carbon monoxide cases involved automobile mechanics or drivers of trucks and other vehicles with closed cabs. F.S.M.

Medical and health programs in industry. Studies in Personnel Policy, No. 17. ANON. *National Industrial Conference Board, Inc.*, Dec., 1939.—Industrial medical and health services in 301 plants employing a total of 621,041 workers are surveyed. Over one third of these establishments employs less than 500 workers, and about two thirds of them employ less than 1000. As has long been suspected, most small plants provide only a minimum of first-aid or emergency medical service. In 88% of the plants there is a medical department under medical or lay supervision. In over 75%, there is either a physician or nurse or both, employed on a regular or part-time basis. In 84%, pre-employment examinations are given, in 5.6% a brief physical inspection is given by a lay attendant, and in 10% no physical inspection of any kind is given. Periodic physical examinations are required or encouraged in over 70% of the companies. Techniques of examinations, follow-up work, and educational and preventive measures all differ widely. The average cost per capita of medical care in 165 plants is $6.12. In small plants both per capita and compensation costs greatly exceed those of large organizations. Among the benefits obtained through plant medical departments were: (1) reduction of lost time; (2) increased efficiency; (3) better employee health and morale; and (4) reductions in compensation and insurance costs. Enquiries concerning this report should be directed to the National Industrial Conference Board, 247 Park Avenue, New York, N. Y. F.S.M.

Occupation and Health. ANON. International Labor Office, Geneva, 1939.—In an effort to keep the two-volume Encyclopedia of Industrial Hygiene (Occupation and Health) up to advancing knowledge and practice, the International Labor Office has decided to publish a supplement. This takes the form, not of a new volume, but of a series of brochures, issued biannually on a loose-leaf plan and adapted for filing and preservation. Each article devoted to a given occupation, process, substance, or health hazard will be published separately to facilitate binding in alphabetical order or replacement by newer articles. The subscription rate for 500 pages is $5.00. The contents of the current supplements are as follows: Acetone and

Homologues, Avian Tuberculosis, Chloroprene, Dioxane, Ethylene Glycol, Ethylene Oxide, Graphite, Navvies' Disease, Occupational Tumours (experimental research, respiratory system, bladder, and bones), and Seleniuretted Hydrogen. F.S.M.

Preliminary Report on Living, Working, and Health Conditions in the Tri-State Mining Area (Missouri, Oklahoma, and Kansas). ANON. Tri-State Survey Committee, Inc., New York, 1939. 35 pp.—The report is based on investigations made by the National Committee for People's Rights on conditions in the Tri-State Mining Area. The material presented is derived from (1) field material, collected by the joint efforts of a trained social investigator and a photographer; and (2) analyses of previous reports on conditions in the Tri-State Area. See "Living . . .," *Ceram. Abs.*, **19** [3] 79 (1940). F.S.M.

Violations of safety orders. ANON. *Workmen's Compensation Statistics, Industrial Commission of Wisconsin*, Dec. 22, 1939.—The Workmen's Compensation Law gives some weight to the "negligence" factor in that it provides that compensation indemnity and death benefits shall be increased by 15% where the injury was caused by the employer's failure to comply with safety orders of the Industrial Commission or the State Safety Statute. Similarly, the Legislature has provided that compensation shall be reduced by 15% where the injury was caused by the employee's failure to use safety devices provided by the employer or to obey reasonable safety rules established and enforced by the employer or because of intoxication. During the 17-year period 1922 to 1938, there were 6405 cases where injury was due to negligence of the employer. The increased indemnity paid in these cases totaled over $465,000, or an average of $27,000 annually. There were nearly 100 cases where the injury was found to be due to negligence of the employee; the resulting reductions averaged less than $400 a year. F.S.M.

PATENT

Use of latex as binder in ceramic materials. GUSTAV HEINZ AND MICHELL CARTER (Gustav Heinz and Edward B. Carter). Can. 386,227, Jan. 9, 1940 (June 14, 1938). G.M.H.

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